**University of Cambridge**

**Department of Archaeology**

# Canaanite Jars from Memphis as Evidence for Trade and Political Relationships in the Middle Bronze Age

**Mary F. Ownby**

Wolfson College

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## DECLARATION

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except where specifically indicated in the text. Excluding cited references, the main text of the dissertation consists of 79,784 words.

Mary F. Ownby
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## ABSTRACT

Trade between two regions often necessitates that the respective parties are political entities. This was indeed the case for trade from the Levant to Egypt during the Middle Bronze Age (ca. 2000-1550 BC, MBA) and Late Bronze Age (ca. 1550-1200 BC, LBA). Scientific analyses of Canaanite jars, transport vessels, from the site of Memphis, Egypt provided an ideal proxy for examining the relationship between trade and politics.

During the MBA, Levantine peoples were present at the site of Tell el-Dab$^{c}$a in the eastern Nile Delta. However, archaeologically there is little evidence for contact between these peoples and the Egyptians at Memphis. The results of comparison of MBA Canaanite jars from both sites suggest that the political situation fostered long-distance trade with the Levant and limited local interaction with the Egyptians.

During the LBA, Egyptian kings controlled territory in the Levant. A comparison of MBA and LBA Canaanite jars from Memphis revealed that the political changes in some cases affected the trade partners but not in others. Further, the production of the jars appeared to have altered in some regions.

These results suggest that the affect of political situations on trade can vary, from only minor changes, to the complete exclusion of trade partners and the introduction of new trade contacts. However, the influence of lucrative trade networks on political developments was also illustrated. The utility of provenance studies of ceramics for providing insight into the complex relationship between trade and politics was confirmed.

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# Chapter 1: Introduction

While the archaeological investigation of trade has received much attention, the relationship between trade and political situations has been difficult to characterize. However, as there is much archaeological and textual evidence for trade and politics in Egypt and the Levant[1] in the Middle and Late Bronze Age, this area provides an ideal testing ground for examining these topics. Further, as some commodities were carried in transport amphorae, called Canaanite jars, the analysis of these jars should help to illustrate trade contacts that can then be examined in light of the political situation. This study will employ petrographic and chemical compositional analyses to identify the provenances of MBA Canaanite jars excavated at the site of Memphis, Egypt. The results will be compared to other MBA and LBA Canaanite jars to illustrate the impact of trade on politics and the influence of politics on trade. Finally, an assessment will be made on whether the provenancing of ceramics can provide valuable information for understanding the relationship between trade and politics.

## *1.1. Aims of the Project*

Many studies of pottery have examined the movement of vessels as evidence for trade, but only infrequently do these studies investigate the political relationships involved[2]. For trade to be conducted between two entities, particularly those across long distances, a certain level of political stability is assumed to exist. The respective partners must be able to successfully produce a product for export and transport that product to the market[3]. However, if one of the partners changes due to political circumstances in their area, what becomes of the established trade connection? Several logical scenarios could occur: the trading contact could be terminated, altered, or continue unchanged. Since goods are traded in a political environment, their analysis should reflect the political relationships that enabled the trade to take place, and if these changed. Further, the lucrative exchange of goods may encourage areas to participate in trade networks and could stimulate political developments in

[1] For this thesis, the term "Levant" is used to indicate the coastal area of modern day Syria, Lebanon, Israel, and Palestine.

[2] Trade is defined as: the exchange of goods, typically as a commercial transaction. Politics is defined as: the activities associated with governing a country or area, and with the political relations between states. Activities often include those aimed at gaining power and status.

[3] This thesis will not discuss the economic institutions in place for trade to be carried out. The research conducted cannot address how the exchange took place or the quantities involved.

those areas.  When examining the complex societies of Ancient Egypt and the Levant, the effect of politics on trade, as well as trade on politics, becomes even more difficult to characterize.  Since goods transported between these two cultures were contained in ceramic vessels, the analysis of these containers should reveal the participants in the trade, the nature of contact, and if changes in trade occurred as the political situations in both areas altered.

Trade from the Levant to Egypt is evident from the discovery of Canaanite jars[4], large transport vessels, found in Egypt but clearly produced in the Levant.  Both the shape of the Canaanite jars and their fabric (i.e. clay, inclusions, and firing) indicate a non-Egyptian origin.  These vessels were significant for the goods they carried, such as wine, oil, and resin (Serpico *et al.* 2003)[5].  As imported commodities in Egypt, they were possibly considered luxury items.  The limited distribution of Canaanite jars in Egypt, particularly in the MBA, further suggests access to the goods they contained may have been restricted.  However, in the LBA, the commodities contained in the jars were probably deemed less valuable as many other precious objects made of gold, silver, glass, wood, and stone were now moving between Egypt and the Levant (Moran 1992).  The value placed on the products carried in Canaanite jars is difficult to assess as there are no documentary sources that discuss the vessels or the goods they held.  For the purposes of this study, and in relation to the political environment in which the jars moved, the commodities they contained will be viewed as luxury items, though of less prestige than gold, silver, glass, wood, or stone objects.  This is important to consider, as high value objects were likely to be under more direct control by political entities than more utilitarian goods (Sherratt & Sherratt 1991).

The discovery of Canaanite jars at the site of Kom Rabi'a, ancient Memphis, dating to the late MBA (ca. 1750-1550 BC) suggests this site was involved in trade during this period.  The overall aim of the present study is to establish where the MBA Canaanite jars found at Memphis were produced through petrographic analysis of thin sections and chemical compositional data.  The resulting data will identify the MBA trading partners with Egypt; information that can be examined the context of the political situation of the period.  In this light, the manner in which the MBA Canaanite jars reached Memphis is not straightforward.  During the late Middle Kingdom and Second Intermediate Period in the Egyptian chronology

[4] Although these vessels are commonly referred to as "storage" jars, they will be called "transport" vessels in this thesis.  Canaanite jars are defined by their function in moving goods as a part of trade (Amiran 1970).
[5] There is some evidence for vessel re-use (see section 3.3.3).

(Table 1.1), the northern half of Egypt was ruled by a dynasty called the Hyksos[6]. These rulers were based at the ancient city of Avaris, present day Tell el-Dab$^{c}$a, and appear to have come to Egypt from the Levant. In contrast, excavations at Memphis have revealed an entirely Egyptian material culture, suggesting Levantine influence was not significant in this area. While few Canaanite jars were uncovered at Memphis, partly due to the relatively small area excavated, vast quantities were recovered from the extensive excavations at Tell el-Dab$^{c}$a (Bietak 1996). Therefore, the extent of contact between the Levantine peoples in the Delta and the Egyptians at Memphis is difficult to ascertain and does not presuppose that Canaanite jars found at the latter site came directly from the former. Petrographic and macroscopic comparisons between the Memphite and Tell el-Dab$^{c}$a MBA Canaanite jars aims to clarify if the jars excavated at Memphis came from Tell el-Dab$^{c}$a, or if the Egyptians had formed their own trading network with the Levant. This information bears directly on our understanding of local trade within Egypt and long-distance trade with the Levant given the political situation of the time.

Table 1.1: General concordance between Egyptian and Levantine chronologies

| Dates | Egypt | Levant |
|---|---|---|
| ca. 2000-1750 BC | Middle Kingdom | early Middle Bronze Age |
| ca. 1750-1550 BC | Second Intermediate Period | late Middle Bronze Age |
| ca. 1550-1000 BC | New Kingdom | Late Bronze Age |

The characterization of trade and politics in the MBA within Egypt and between Egypt and the Levant is the primary focus of this research. An additional method for examining the complexities of trade and politics during this period is to study how trade changed in the LBA when the political situation in both Egypt and the Levant was altered. The results of scientific analyses of LBA Canaanite jars from Memphis provides a core set of data for investigating changing patterns of importation from the Levant (Bourriau *et al*. 2001; Serpico *et al*. 2003; Smith *et al*. 2004). While Egypt was divided between the Hyksos dynasty in the Delta and Egyptians further south during the Second Intermediate Period, this situation changed when the Egyptians regained complete control of Egypt at the beginning of the New Kingdom (ca. 1550-1000 BC). Thus, during the MBA most trade probably occurred

[6] The term ‘Hyksos’ is the Greek version of the Egyptian *hekau khasut* (*hk3w-h3swt*) meaning ‘rulers of foreign/mountainous countries’ (Bourriau 2000: 187). In this thesis, the term is used for the 15$^{th}$ Dynasty rulers based at Tell el-Dab$^{c}$a (see section 2.2.3).

between groups in the Levant and the mixed Levantine-Egyptian population in the Delta. However, in the LBA, trade was carried out between the Egyptians and Levantine city-states, most of which were under Egyptian control. In addition to this Egyptian "empire"[7] in the Levant, other powerful empires were active in the Eastern Mediterranean. While trade in commodities transported in Canaanite jars was significant in the LBA, many other goods, such as copper, now played a dominant role (Muhly 1986). Thus, examination of Canaanite jars can only inform on one aspect of LBA trade. Nevertheless, the comparison of the MBA and LBA Canaanite jars at Memphis aims to determine if changes occurred in the trading networks and how political events may have influenced these changes. This charaterization of LBA trade and politics will provide a means for assessing how MBA trade and politics may have interacted in ways different from the LBA.

Thus, several research questions have been proposed and a set of ceramic material is available for analysis to provide data to address these questions. First, petrographic and chemical analysis of the MBA Canaanite jars from Memphis will suggest where these jars were produced. Then, through a comparison of this corpus with the MBA Canaanite jars at Tell el-Dab$^{c}$a, the relationship of these two corpora will be established and any political connections between the two groups assessed. The comparison of the MBA and LBA Canaanite jars from Memphis will reveal changes in areas exporting goods to Egypt, which will be interpreted in light of the concomitant political developments in Egypt and the Levant. These results will be utilized to characterize the unique aspects of trade and politics in the MBA. Further, the study aims to examine the extent to which politics can affect trade networks, such as removing some partners, introducing others, or having no effect at all. Conversely, the influence of trade on politics will be considered to ascertain if trade provided an incentive for political change in an area or appears to have played a minimal role in political developments. Finally, the utility of technical analysis of ceramics to provide a more comprehensive understanding of the context of their movement will be considered.

[7] The term "empire" is commonly used in the literature to refer to the area of the Levant under Egyptian control during the New Kingdom. However, unlike most empires, Egypt did not heavily occupy this area and instead built administrative centers that oversaw the territory (see Chapter 2).

### *1.2. Theoretical Background*

Theoretical discussion of trade in ancient societies began with the political economic analyses by Polanyi (1957)[8]. Polanyi represented the substantivist movement in anthropological theory that saw individual economies developing from particular socio-cultural settings (Manning & Hulin 2005: 271-272; Monroe 2005: 157). On the other hand, the formalists suggested universal parameters, based on modern concepts of supply and demand, for the development of prehistoric economies. The former theoretical perspective became dominant in the examination of ancient trade, with emphasis placed on the relationship between intercultural contacts and the emergence of cultural complexity (Renfrew 1969; Adams 1974). However, the models that developed took little notice of the influence of other factors, such as politics, on how trade was conducted. One exception was Adams (1974), who suggested that such an approach was necessary, and illustrated an example of the impact of trade on politics within the Near East.

While still examining the affects of trade on cultural development (following from a neo-evolutionary approach in anthropology), the theoretical discussion in the 1970s began to focus on characterizing different types of exchange, their archaeological patterns, and the role trade played within particular societies (Sabloff & Lamberg-Karlovsky 1975; Earle & Ericson 1977; Hirth 1978). These models considered the effects of particular socio-cultural settings on exchange; however, little attention was given to clarifying the interaction of social systems and trade. Beginning in the 1980s, trade was examined in relation to specific socio-cultural contexts that included political systems, but again, few conclusions were reached on the influences of politics on trade (Ericson & Earle 1982). The theoretical framework known as “peer polity interaction” also investigated trade between socio-political units, but did not clarify the relationship between trade and politics (Renfrew 1986).

Other theoretical perspectives examined the role of the accumulation of wealth by elites through trade items, i.e. prestige good theory (Brumfiel & Earle 1987). Within this model, the influence of trade on politics, as controlled by elites, was paramount, while the effects of politics on trade were rarely acknowledged (Schortman & Urban 2000: 198-199). Another theoretical approach to the movement of objects between ancient societies utilized the world systems theory of Wallerstein (1974, 1980). While this theory gave trade a primary

[8] The movement of goods between two groups has been discussed theoretically as trade, which implies formalized, economic systems, and/or exchange, which encompasses all mechanisms for the movement of objects and intrasocietal contacts (Renfrew & Bahn 2008: 357). For the current discussion, the term utilized in the publication will be employed.

role and examined it in relation to other cultural systems, it was based on the development of western society and had to undergo significant modification for archaeological applications (Schortman & Urban 1987: 55-62; Schortman & Urban 2000: 197-198). The most recent overview of trade theory (Renfrew & Bahn 2008: 356-390) suggests little advancement in the archaeological understanding of trade and its relation to political contexts.

Within the study of trade in the Eastern Mediterranean, several scholars have utilized these theoretical frameworks. Smith (1965) was influenced by theories of the effect of trade on cultural development. Algaze (1993), Kohl (1987, 1996), and Cline (2000) examined world systems theory in relation to different groups and periods in the Near East. However, for the current study, world systems theory is difficult to utilize because defining the Levant as a periphery to Egypt is inappropriate, as both areas had their own political systems and contacts are more accurately viewed as between two "core" areas. On the other hand, the integration of politics into studies of trade in the Near East have been more significant, probably because textual evidence illustrated the political nature of the societies involved and their interaction (Hawkins 1977).

Within the Eastern Mediterranean, prestige goods theory has been utilized by Sherratt and Sherratt (1991) who emphasised the need of elite groups to acquire small amounts of valuable materials, which resulted in larger scale production of commodities for export and the development of trading networks. As most of the trade was under royal or elite control, political processes were also involved. However, similar to the approach taken by Knapp (1993), the influence of trade on the participants is given more weight than any changes in politics.

This preoccupation with elite consumption in relation to political developments is due in part to the visibility of high-status goods typically made from precious metals and exhibiting remarkable craftsmanship (Manning & Hulin 2005: 282). However, the movement of bulk commodities must also have had a political aspect, particularly as they were probably distributed outside of elite realms. Therefore, if the consumption of all types of goods is viewed as integrated within political processes, as a part of elite status and power, then the study of consumption should provide a means for examining the relationship between the acquisition of trade goods and specific political situations (Manning & Hulin 2005: 287, 291). The current study attempts just such an examination through the analysis of goods consumed in Egypt that were transported in Canaanite jars.

While more recent research in the Eastern Mediterranean has continued to emphasis the dominance of trade on politics, i.e. Stager's (2001) "port of power" model for trade between southern Palestine and Egypt in the Early and Middle Bronze Age, others have begun to examine the complicated relationship between political situations and trade. Liverani (2003) studied the changes in Eastern Mediterranean trade between the Late Bronze Age and early Iron Age, while also considering political factors. The results suggested that politics could either encourage or disrupt trade, while trade could influence political events (Liverani 2003: 119). Further, this study illustrated a method for examining the influences between politics and trade by comparing the trade patterns and political scenarios between two periods where both were manifestly different. A similar approach is adopted in the current study, where comparison of trade and politics between the MBA and LBA will be utilized to assess the degree to which each was significant for this region and period.

The current research will focus on the interaction between trade and politics with both a synchronic and diachronic perspective. The approach will be based on the contextualization of trade within the area and societies under study, but will focus on the part of that context that involves the relationship between politics and trade, including both local and long-distance trade. From the above discussion, it becomes clear that more recent attempts to examine these aspects of culture have given emphasis to the dominance of trade in politics, but several case studies have illustrated the opposite. Therefore, the first hypothesis to be examined in the current study is that political disruption within the areas producing and receiving commodities will affect trade. This statement is devoid of a nuanced understanding of the variability in reactions by both partners to an enormous range of political disturbances. The second hypothesis is that the production and consumption of goods by specific groups played a large role in the political configuration of the entities involved. This theory, in which trade is the primary motivating factor in the politicizing of ancient societies, has been supported in certain cases, but needs clarification as other political motivations may have taken precedence over economic gain through trade. In order to examine these concepts, the suggestion by Manning and Hulin (2005: 291) to study the influence of trade on politics through analyses of consumption has been heeded, with the work of Liverani (2003) providing a preliminary model. Thus, by characterizing the consumption of Canaanite jars at Memphis within the framework of the political situations of the time, new insights will be gained on the complexity of the relationship between trade and politics.

## *1.3. Contribution to Debate*

The visibility of Canaanite jars as obvious representations of trade from the Levant to Egypt has encouraged scientific analyses to determine their origin. McGovern utilized Neutron Activation Analysis (NAA) to acquire chemical compositional data from samples of Canaanite jars and other imported pottery excavated at Tell el-Dab$^{c}$a (McGovern & Harbottle 1997; McGovern 2000). The data were compared to an existing NAA database of pottery samples from the Levant. The results suggested that the majority of the vessels were made in southern Palestine. This was taken as evidence that the peoples of Avaris originated in Palestine and maintained strong trade connections with their homeland. However, there were several problems with the study that raised doubts about the conclusions (Bourke 2002; Goren 2003; Aston 2004c)[9]. The most important issue was the comparative database, which was based on samples of pottery that had not been proven to be local productions from the sites where they were found. This meant they could not be employed in tying unknown ceramic material to these sites. Furthermore, the database had little comparative material from the northern Levant, so it was unsurprising that most of the data tended to fall into groups with the southern Palestinian samples. Other problems were the broad generalizations made for the whole ceramic corpus at Tell el-Dab$^{c}$a based on the non-randomly selected material analyzed, and the use of transport vessels to infer ethnicity. Finally, the statistical approach to the data did not account for how these tests work with the data or that analyzing groups of very different composition together will create a false sense of commonality between samples with only superficial similarity.

Due to these issues, a petrographic study of the foreign pottery from Tell el-Dab$^{c}$a was subsequently undertaken (Cohen-Weinberger & Goren 2004). This study identified eleven fabric groups that could be assigned to geological areas in the Levant. Over 70% of the imported vessels were from the northern Levant. The remaining vessels were from southern Palestine. This pattern suggested that the peoples at Tell el-Dab$^{c}$a had closer trade connections with the northern Levant. The incongruity between the two studies is significant in terms of understanding trade connections between Egypt and the Levant during the MBA. The current study of the Memphite MBA Canaanite jars will provide additional data to identify the trade partners with Egypt in this period.

A further area of research that could benefit from the scientific analysis of Canaanite jars is the clarification of the political situation in Egypt during the late Middle Kingdom and

[9] For a more positive book review see Hulin (2002b).

Second Intermediate Period. The textual sources describe the rule of Egypt as divided between the Hyksos in the north and the Egyptians in the south (Redford 1997: 13-15). However, this information derives from Egyptian royal propaganda and may not reflect the historical situation. The archaeological evidence reveals that the unique mixed Egyptian and Levantine culture exhibited at the site of Tell el-Dab$^{c}$a has been found only at a few other sites in the Eastern Nile Delta, such as Tell el-Maskhuta, Tell el-Muqdam, and Tell el-Yahudiyeh (Petrie 1906; Holladay 1997; Bourriau 2000: 190)[10]. Further south, evidence for contact with the Delta has been the discovery of Tell el-Yahudiyeh ware, Canaanite jars, and Hyksos scarabs. Tell el-Yahudiyeh ware has a much broader distribution than Canaanite jars within Egypt, being found from the Delta south to the site of Kerma in Nubia (Kaplan 1980; Bietak 1989a)[11]. Most of these vessels appear to have been made in Egypt and distributed throughout the Nile Valley (Kaplan *et al*. 1982; Bietak 1989a). Similarly, most of the Hyksos scarabs in Egypt are likely to be local productions (Ben-Tor 2007b). The distribution of both object types does not seem to suggest a significant presence of peoples from Tell el-Dab$^{c}$a outside of the Delta.

As Memphis is relatively close to Tell el-Dab$^{c}$a, this site should exhibit evidence for Levantine influence, especially since textual sources specify that it was under Hyksos control. However, a comparison between the Egyptian ceramics at both sites revealed that while initial similarities existed, these were superseded by marked differences during the Second Intermediate Period (Bader 2007; 2008; 2009). The lack of MBA material culture indicates there was no significant Levantine presence at the site. Thus, recent archaeological data have suggested the Hyksos did not directly rule Memphis, although a more remote form of domination could have been possible. Comparison of the MBA Canaanite jars from Memphis with those at Tell el-Dab$^{c}$a could assist in understanding contact between the mixed Egyptian/Levantine population in the Eastern Nile Delta and the Egyptians at Memphis.

The study of interregional trade during the LBA in the Eastern Mediterranean has received a significant amount of attention. Research has focused on a variety of textual and archaeological sources that indicate consistent and frequent trade between Egypt and the Levant (Merrillees 1974; Liverani 1990; Gale 1991). This contact was facilitated by the establishment of an Egyptian "empire" in the Levant and diplomatic relationships with the

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[10] Exploration of the Western Delta has been minimal, so the presence of MBA material culture in this area is difficult to determine.

[11] The work by Kaplan is notable for outlining the distribution of the ware, but inconsistencies in the typology raised questions (Bietak 1989a: 7). A typology developed by Bietak (1989a) was based on excavated vessels from Tell el-Dab$^{c}$a. Chronological problems with Kaplan's work were discussed by Weinstein (1982).

surrounding empires. However, little focus has been given to changes in trade between the MBA and LBA, or to utilizing scientific data that may clarify the extent of trade relations in the Eastern Mediterranean. One notable exception is the scientific analyses of LBA Canaanite jars from Memphis (Bourriau *et al*. 2001; Serpico *et al*. 2003; Smith *et al*. 2004). This study suggested that Canaanite jars imported to Egypt came from many localities along the northern coast of the Levant and Cyprus. As MBA Canaanite jars were also found at Memphis, they provide a unique and valuable opportunity to investigate the diachronic change in trade that may relate to the evolving political situations in Egypt and the Levant.

The study of the MBA Canaanite jars from Memphis will also assess the utility of petrographic analysis of transport vessels for providing insight into the relationship between politics and trade. Most studies employing petrography to study ceramics have focused on the identification of the provenance of the material and reconstructing the movement of the vessels. Few studies have taken this information and attempted to interpret the patterns in relation to the political environment (exceptions include McGovern 2000 and Master 2003)[12]. Furthermore, only a few studies have examined the diachronic change in trade patterns and how this may reflect the development of the political entities involved in trade. The scientific analysis of transport vessels presented in this thesis aims to go beyond the identification of trading partners to examining the political context of the trade. The success of this analysis will be largely dependent on the rigour of the data and the advantageous opportunity of discussing trade between two literate and archaeological well-known cultures. The results and interpretations should reveal if analyses of these types could provide a clearer understanding of the complicated dynamic between trade and politics.

### *1.4. Methodology*

Within ceramic studies, an established technique for determining the location of production of an object (i.e. provenance) is thin section petrography. This method, borrowed from the geological and soil sciences, allows for the identification of the mineral constituents and clay types utilized in producing pottery. Since these components were probably derived from geological sources near where the vessel was manufactured, their identification indicates the types of geological outcrops characteristic of the local environment. Using mineralogical information, geological maps, and comparative material, be it ceramics or raw

[12] Petrographic analysis of clay tablet letters exchanged between Egypt and the Eastern Mediterranean during the LBA integrated scientific, archaeological and textual information to clarify political relationships (Goren *et al*. 2004).

materials, a source for the pottery can be postulated. An additional technique for determining ceramic provenance is chemical compositional analysis. These data can be compared to data deriving from other samples to determine similarity, or in the case of material from kilns, provenance. Likewise, the results can suggest if several workshops were in operation within an area that is geological similar, for which petrography may not have identified the products of various manufactures. The employment of both techniques provides a more rigorous data set for identifying the provenance of ceramics. However, the results must be interpreted cautiously as they may provide different conclusions. An example of this scenario occurred within the field of Egyptology, where petrographic information, compositional data, and vessel form analysis arrived at divergent conclusions[13].

For the study of the MBA Canaanite jars from Memphis, both thin section petrography and chemical analysis were conducted. The selected samples were taken from the range of fabrics identified in the field, based on the fabric classification system developed for this material. This was done with the aim of bringing material from the excavation that was not sampled for analysis into the study, through the relationship between scientifically postulated provenance group and fabric group. Additionally, the vessel forms identified in each fabric group could be interpreted in light of the suggested provenance of the samples in that fabric group. Thin sections of the Memphite MBA Canaanite jars also provided a set of data for comparison to the MBA Canaanite jars from the site of Tell el-Dab$^{c}$a. Additionally, comparison with a binocular microscope of jar sherds from Tell el-Dab$^{c}$a and images of the Memphite sherds allowed for further investigation of the relationships between the corpora. Thin sections and chemical data from the Memphite MBA Canaanite jars were compared to the same type of data from the LBA Canaanite jars. The applied methods produced interpretable data that related directly to the origin of the MBA Canaanite jars at Memphis, their relationship to the jars at Tell el-Dab$^{c}$a, and changes in importation of the vessels to Memphis between the MBA and LBA.

### *1.5. Overview of Thesis Chapters*

This thesis presents the research context, methodology, and results from the analysis of the MBA Canaanite jars from Memphis, along with its contribution to understanding trade

[13] This involved the analysis of EBA Canaanite jars from Abydos (Tomb U-j) where the vessel shape, NAA data, and a combined XRF/petrographic study suggested they were Levantine, while a separate petrographic investigation suggested most were produced in Egypt (Hartung 2001: 345-387; McGovern 2001; Pape 2001; Porat & Goren 2001).

and politics in the MBA.  Chapter 2 discusses the political history of Egypt and the Levant in the MBA and LBA as the context for the research conducted.  The focus is on evidence for contacts between the two areas from ca. 2000 to 1200 BC.  In Chapter 3, the excavations at Kom Rabi'a that produced the sampled MBA Canaanite jars are described, while the second half of the chapter discusses Canaanite jars and evidence for their use and distribution. Chapter 4 outlines the samples and methodology.  The results of the petrographic and chemical analyses of the MBA Canaanite jars from Memphis are presented in Chapter 5, while Chapter 6 comprises the discussion of the thin section and fabric comparison of the Memphite and Tell el-Dab$^{c}$a MBA jars.  The results from the petrographic and chemical comparison of the MBA and LBA Canaanite jars from Memphis are given in Chapter 7. Finally, Chapter 8 discusses the contribution of the research to understanding trade and politics during the MBA, as well as the effectiveness of the research in showing the utility of scientific analysis of ceramics to understanding these cultural phenomena.  While these eight chapters represent the bulk of the research conducted, four appendices include additional information on the analytical procedures, fabric and petrographic description of each sample, the chemical compositional data, and point-counting data.

# Chapter 2: Historical Background: Egypt and the Levant in the Middle and Late Bronze Age

## 2.1. *Introduction*

The nature of the contacts between Egypt and the Levant underwent many changes during the Middle and Late Bronze Age. During the MBA, archaeological, textual, and pictorial evidence suggests that trade took place, but prior to the establishment of the large Levantine population at Tell el-Dab$^{c}$a the evidence is difficult to assess. By the time the Hyksos dynasty gained power in the Delta, movements of goods and people between this area and the Levant appears to have taken place on a regular basis. During the LBA, Egypt was politically unifed and acquired territory in the Levant. These events impacted the relations between the two areas, particularly as Egyptians now appeared to be living in the Levant at a few administrative sites. This chapter will provide an overview of these historical and political developments to provide a context for the examination of the trade that occurred[14].

## 2.2. *The Middle Kingdom and Second Intermediate Period in Egypt*

### 2.2.1. Middle Kingdom in Egypt, Dynasty XII

The Middle Kingdom began with the reunification of Egypt under a Theban king, Nebhepetre Mentuhotep II (Callendar 2002). Previously, during the First Intermediate Period, the country was ruled by kings at Thebes and Herakleopolis, as well as some powerful provincial nomarchs. The unification of Egypt under a strong line of kings, the 12$^{th}$ Dynasty, heralded a prosperous period (Table 2.1; von Beckerath 1984: 82-87; Franke 1988a; Grajetzki 2006; Schneider 2006: 170-175). From their capital at Itj-tawy (believed to lie near the site of Lisht) these kings renewed contacts with the city-states of the Levant (Fig. 2.1)[15].

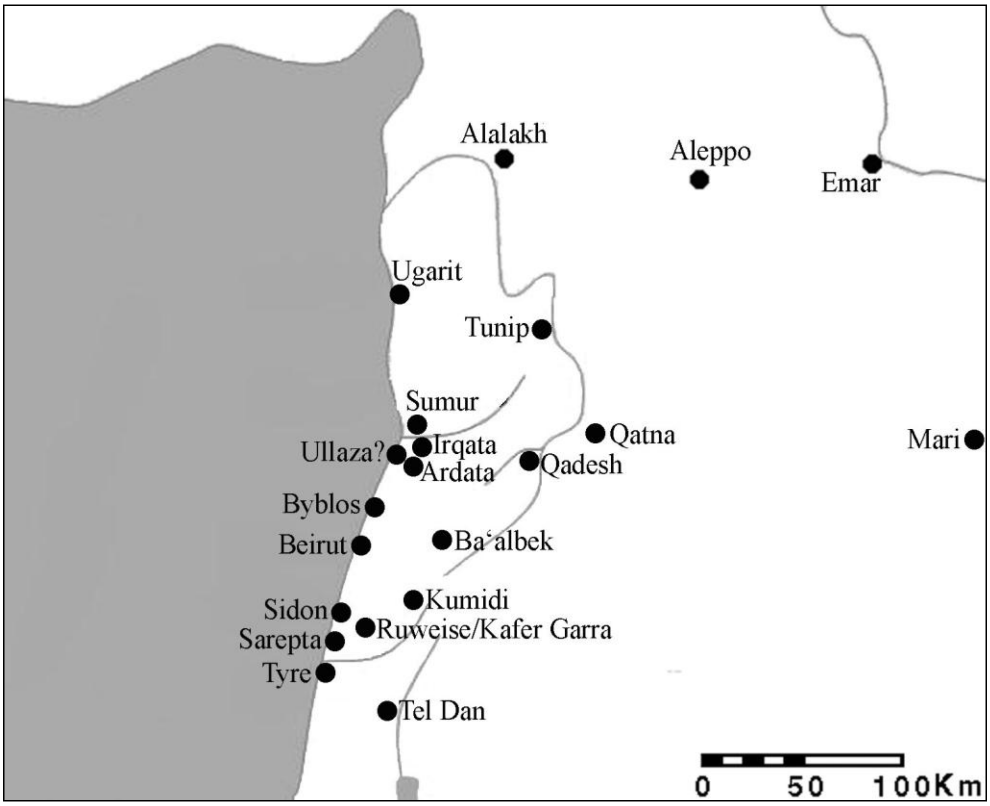
[14] All sites mentioned in the text can be found on Figs. 2.1 (northern Levant), 2.2 (southern Levant), 2.3 (Egypt), and 2.6 (Nubia).

[15] Contacts between Egypt and the Levant are clearly evident in the Old Kingdom/Early Bronze Age, particularly with the site of Byblos (Montet 1928: 270-274; Jidejian 1971: 15-17; Saghieh 1983: 104-106; van den Brink & Levy 2002; Bietak 2007a: 417-419).

Table 2.1: Kings of the 12th Dynasty (after Grajetzki 2006: 169)

| Nomen | Prenomen |
|---|---|
| Amenemhat I | Sehetepibre |
| Senusret I | Kheperkare |
| Amenemhat II | Nubkaure |
| Senusret II | Khakheperre |
| Senusret III | Khakaure |
| Amenemhat III | Nimaatre |
| Amenemhat IV | Naakherure |
| Sobekneferu | Sobekkare |

Fig. 2.1: Archaeological sites in the northern Levant

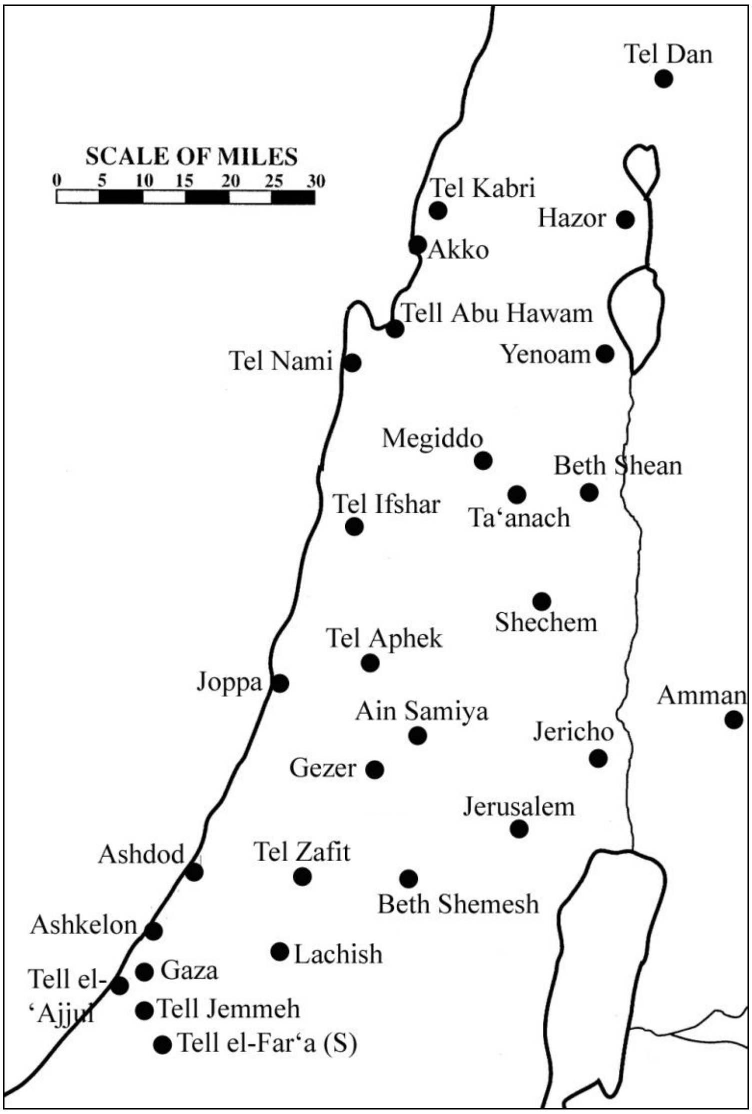



The evidence for these contacts comes from textual, pictorial, and archaeological sources[16]. An inscription on the stela of the General Nesmont in the reign of Amenemhat I only specifies attacking people in an unidentified location (Grajetzki 2006: 31). The Prophecy of Nerferty dated to the reign of Senusret I claims that 'Asiatics'[17] have caused problems in Egypt, although these are likely to be people from Sinai and possibly southern

[16] Redford's (1992) ideas have been largely superseded. See (Rainey 1994) for comments and the response by Redford (1996).
[17] The Egyptian term 'Amu is translated as "Asiatics" and appears to refer to people from the Near East (Posener 1971: 534)

Palestine (Lichtheim 1973: 141). The Tale of Sinuhe, in which the Egyptian Sinuhe imposes self-exile in Palestine, seems to imply that Senusret I had little interest in the Levant, but does mention the cities of Byblos and possibly Qatna, and the area known as Cilicia (Fig. 2.2; Lichtheim 1973: 222-235; Schneider 2003; Rainey 2006: 292-293). Further, the text indicates that communication between Egypt and this area occurred, including the sending of gifts to foreign rulers. Other inscriptions seem to confirm that Egyptians visited the Levant, while administrative documents provide strong evidence for 'Asiatics' living in Egypt (Schneider 2003: 232-290). Inscriptions in the Sinai also suggest 'Asiatics' probably from the area and southern Palestine were involved in mining (Gardiner *et al*. 1955: 19; Seyfried 1981: 190-201).

Fig. 2.2: Archaeological sites in the southern Levant

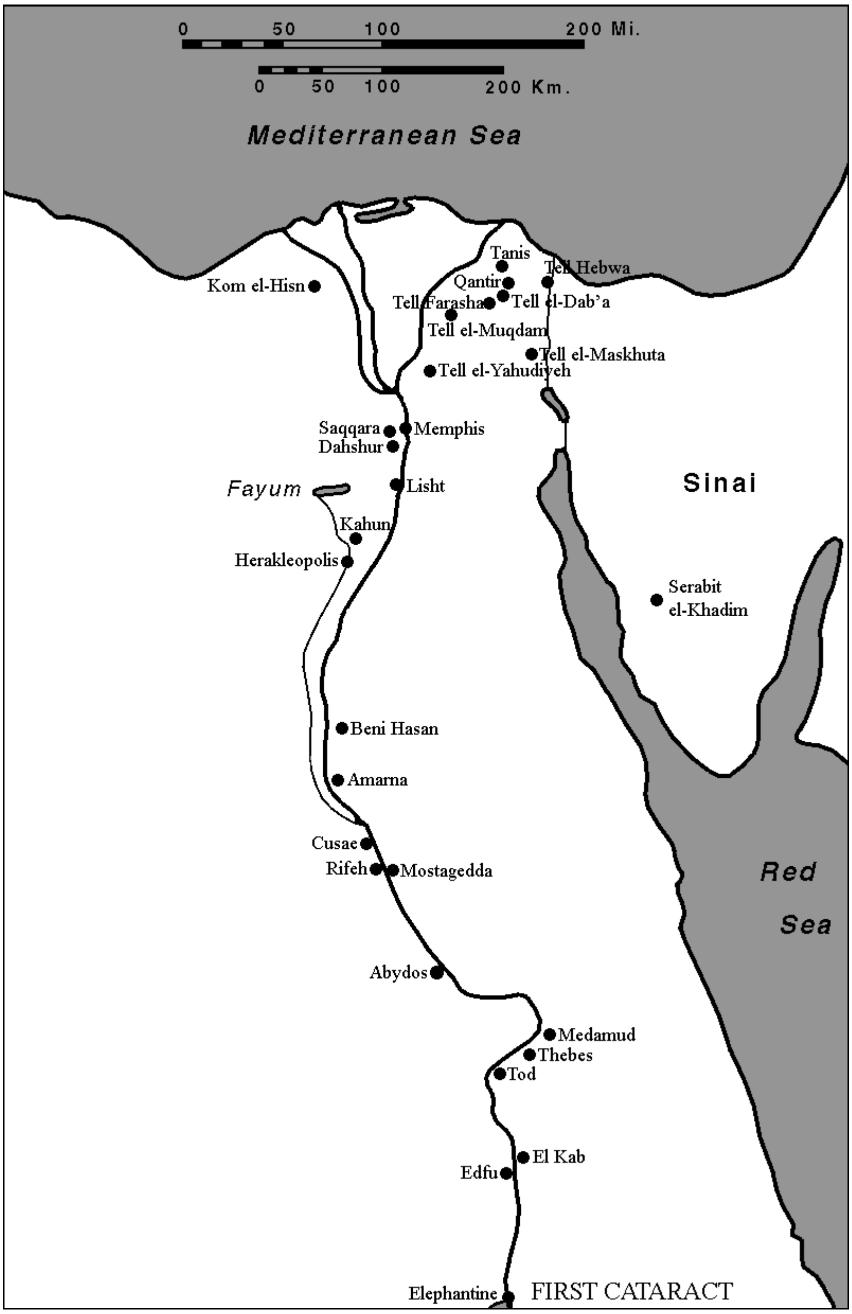


One of the most informative sources is an inscription found at Memphis dating to the reign of Amenemhat II (Altenmüller & Moussa 1991; Goedicke 1991; Malek & Quirke 1992; Marcus 2007)[18]. The text mentions peoples from 'Asia' arriving in Egypt with goods as part of a possible diplomatic and trade mission. Further, it describes several expeditions to coastal Lebanon, and possibly other locations, to acquire a wide range of goods[19]. The variety of commodities listed suggests several ports of call to collect all the items, either through trade or as mentioned in the text as tribute, possibly due to the threat of military action. The bringing back of Levantine peoples also provides a possible explanation for their presence in Egypt at the time. Interestingly, the text states the goods were then redistributed in Egypt to either members of the military on the expeditions or to various temples.

A scene and its accompanying caption in the tomb-chapel of Ukh-hotep, dated to either to the reign of Amenemhat II or Senusret III, mentions cattle from 'Asia' being brought to Egypt (Blackman 1915: 13, Plate IV). An expedition by Senusret III is recorded by one of his soldiers, Sebek-Khu (Khuusobek), against the Mentiu-Sati people in lands called Sekmem (Shechem?) and Retjenu (Fig. 2.3; Garstang 1901: 6, 32-33, Plate V). The latter is a well-known Egyptian term for Syria-Palestine. A more obscure inscription mentioning the Levant in this king's reign is on a block from Medamud, which seems to imply goods from 'Asia' were brought to the palace (Bisson de la Roque 1927: 67).

[18] Goedicke (1991: 91-92) reconstructs the name of one of the cities as possibly Tunip, now thought to be the site of Tell ʿAsharneh on the upper Orontes (Klengel 1995).
[19] The text mentions 92 *hnw* vessels carrying incense (*snṯr*). As residue analysis of LBA Canaanite jars labelled *snṯr* suggests these jars were carrying resin, this may be a textual reference to the movement of Canaanite jars from the Levant to Egypt (Serpico *et al*. 2003) (See section 3.3.3).

Fig. 2.3: Archaeological sites in Egypt




The tombs of high officials during the Middle Kingdom contain images of foreigners called Asiatics and inscriptions mentioning them. The tomb of Khnumhotep I at Beni Hasan, dated to the reign of Senusret I, includes a scene of a group of ‘Asiatic’ warriors along with an inscription describing attacks against ‘Asiatics’; the precise location was not specified (Fig. 2.4; Newberry 1893: 84-85, Plates XLIV and XLVII; Ward 1971: 66). Also at Beni Hasan is the famous tomb of Khnumhotep II, the son of Khnumhotep I, dating to the reign of Senusret II. It features ‘Asiatics’ that are bringing eye-paint to Egypt (Fig. 2.5; Newberry 1893: 57, 69, Plates XXX and XXXI; Kamrin 2009). An inscription found outside a mastaba tomb at Dahshur belonging to Khnumhotep III, the son of the above mentioned Khnumhotep II, is dated to the early reign of Senusret III (Allen 2008). It describes a conflict between Byblos and Ullaza (probably Tripoli), in which Egypt sides with the latter city. Other information in the inscription suggests that in the 12th Dynasty Egypt was trading mostly with Ullaza to acquire cedar. Egypt appears to have played a role in the political situation of the time and may have even sent troops to assist in resolving the issue.

Fig. 2.4: Tomb Scene of 'Asiatic' warriors, tomb of Khnumhotep I, Beni Hasan (Newberry 1893: Plate XLVII)

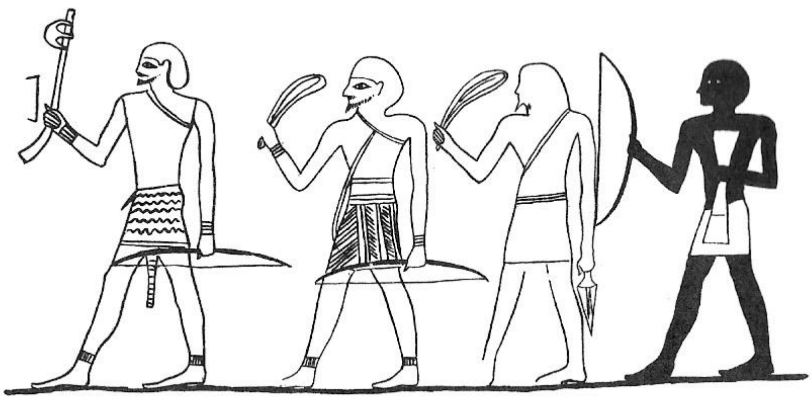


Fig. 2.5: Tomb Scene of 'Asiatic' traders, tomb of Khnumhotep II, Beni Hasan (Newberry 1893: Plate XXXI)

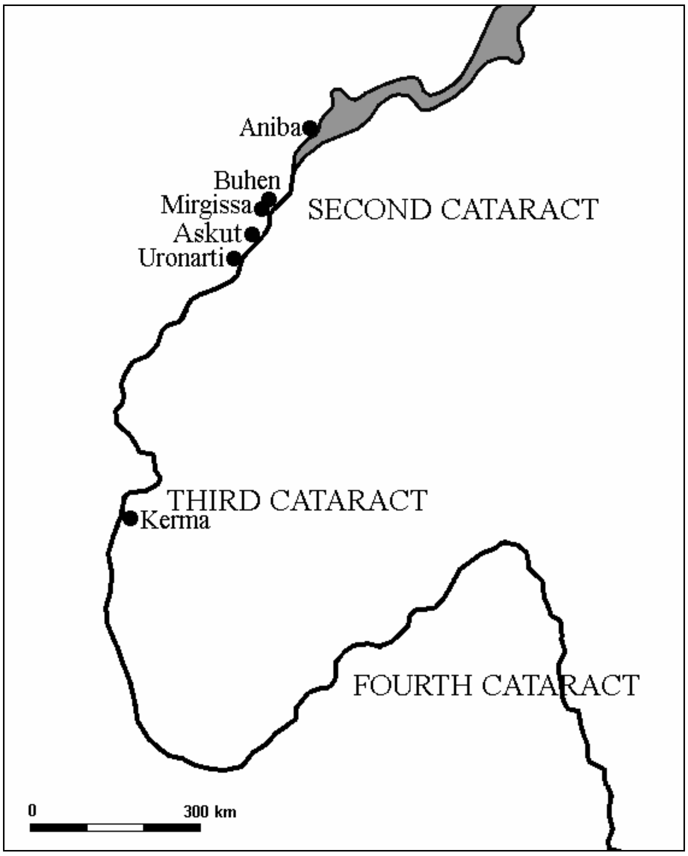
The redistribution of Levantine objects stated in the inscription of Amenemhat II recalls the discovery in the Temple of Montu at Tôd of four copper chests inscribed with this king's cartouches, the so-called Tôd Treasure (Bisson de la Roque 1950; Bisson de la Roque *et al*. 1953)[20]. Within the chests, the majority of objects were ingots of silver and lapis lazuli along with silver vessels, cylinder seals and amulets of lapis lazuli. These materials are not native to Egypt and most of the objects are of clear foreign design. The decorative form of many of the silver cups is either Aegean or Levantine but inspired by Aegean examples (Posener 1971: 543-544). Some of the cylinder seals were of Syrian, Mesopotamian, and even Iranian/Persian design and dated to a range of periods (Porada 1982). However, many of the cylinder seals were broken and the silver cups had been flattened. Most likely, the objects were gathered over an extended period at a site probably in coastal Syria and then sent to Egypt as raw materials, and from there donated to the temple.

The so-called Execration Texts are often cited as evidence for Egypt's familiarity with cities in Palestine (Posener 1971: 505-509; Redford 1992: 87-93; Grajetzki 2006: 136). Comprising inscribed figurines and pottery vessels, these objects were broken so as to nullify the power of the enemies listed, including rulers, towns, and areas. The earliest group includes the clay figurines and pottery from the fortress at Mirgissa (Fig. 2.6; Vila 1963; Posener 1966), dated to shortly after the reign of Amenemhat II, followed by the pottery now housed in Berlin (Sethe 1926), dated to the mid-12th Dynasty (probably reign of Senusret III) based on the ceramic bowl forms[21]. The last group comprises the figurines found at Saqqara and housed in Brussels, probably dating to the beginning of the 13th Dynasty (Posener 1940; Weinstein 1975: 13; Ben-Tor 2006b: 64-66). The towns mentioned in the Mirgissa inscriptions include Byblos, Ullaza (Tripoli?), two unidentified towns (probably 'naqi and Mugar), and a region in Transjordan called Shutu. The Berlin texts list the sites of Araqata (Irqata, Tell 'Arqa), Ullaza, Byblos, and Ashkelon, as well as several areas in inland Palestine. Finally, the Brussels inscriptions include many town names within Palestine, such as Akko, Shamkhuna, Jerusalem, Lachish, and Beth Shemesh, and several important inland regions such as the Orontes, Damascus, and the Jordan Valley. However, a recent re-examination of these objects, in light of the archaeological excavations carried out in Palestine, suggests these lists are formulaic inscriptions copied from Old Kingdom texts

[20] Though the date of these objects is debated, most evidence points to their being dated to the reign of this king (see Pierrat 1994).
[21] These were examined by Do. Arnold and the results published by Rainey (2006: 290).

(Ben-Tor 2006b). For this reason, and as the purpose of these objects was not to enumerate places in the Levant, the information they provide must be examined cautiously.

Fig. 2.6: Archaeological sites in Nubia

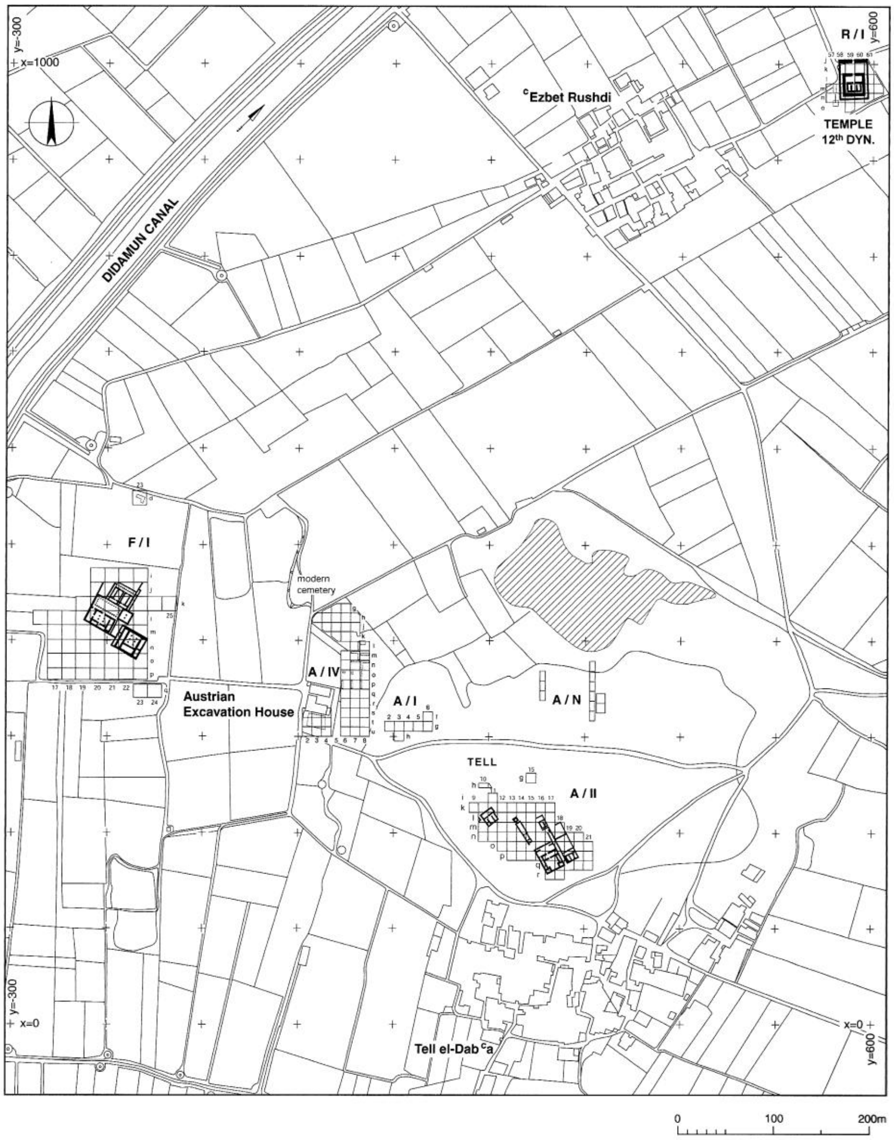



Further archaeological evidence comes from foreign pottery found on Egyptian sites. Several pieces of Levantine pottery, estimated to date to the 12th Dynasty, were found at Kom el Hisn (Hamada & Farid 1947: 197-198)[22]. The site of Kahun, dated from the reign of Senusret II to Amenemhat III, produced a number of fragments of foreign pottery (Petrie 1891: Plates 1.11, 1.16, 1.19, and 1.22). Levantine pottery found at Lisht, near the capital of Dynasty XII, was dated to the late 12th Dynasty (Arnold *et al*. 1993). This may indicate foreign vessels were being imported by the palace. Some examples derive from the nearby site of Dahshur (Arnold 1982: 41-42). However, with the notable exception of Tell el-Dab^c^a,

[22] MBA weapons were also found at the site (Orel 2000: 40; Philip 2006: 225, 231-232) and Tell el-Yahudiyeh ware sherds dated to the 13th Dynasty and Second Intermediate Period were found in a recent survey (Kirby *et al.* 1998). Its location in the Western Delta probably indicates more sites with MBA cultural remains are in this relatively unexplored part of the Nile Delta.

few other sites reveal contacts during this period[23]. The area known as ᶜEzbet Rushdi near Tell el-Dabᶜa featured an Egyptian settlement dated to the end of the 12th Dynasty (Fig. 2.7, Bietak 1996: 9-10). Within this area were found sherds of Canaanite jars and imported jars/jugs (Bagh 1998). Based on petrographic analysis, these vessels originated from areas along the Levantine coast as far north as Syria and south to the site of Ashkelon (Cohen-Weinberger & Goren 2004: 80, 92).

Fig. 2.7: Areas excavated at Tell el-Dabᶜa, showing the 12th Dynasty temple (R/I), the late Middle Kingdom Palace (F/I), and the Second Intermediate Period temple precinct (A/II) (Bietak 2002: Fig. 1)




[23] However, the vagaries of excavation, which have focused predominantly on Middle Kingdom tombs rather than settlements, must be considered in arguments *ex silentio*. The above mentioned pieces of foreign pottery were mostly found in settlement contexts.

In the later 12th Dynasty, a new settlement was built at Tell el-Dab<sup>c</sup>a (Stratum H=d/2 in Areas A/II and F/I)[24] featuring houses with a Levantine layout (*Mittelsaal* and *Breitraum* types) (Bietak 1996: 10, 2007: 424; Bietak *et al*. 2001: 171). These are similar to houses of the same date at Mari. At a slightly later date Egyptian houses were present as well. The appearance of graves in the settlement may reflect an urban Levantine custom, although the tomb construction was of Egyptian derivation, and the funerary goods were mixed Egyptian/Levantine (Bietak 1996: 10; Schiestl 2002: 329-341, 2009). The ceramic repertoire consisted of mostly Egyptian vessels and only 20% MB IIA[25] ceramic forms (Bietak 1991a: 32-33; Aston 2002). The imports were mostly coming from the northern Levant based on petrographic analysis (Cohen-Weinberger & Goren 2004: 80, 92). The MBA culture[26] evident was by no means homogenous, reflecting the influx of Levantine peoples from many areas, particularly the more urbanized northern Levant (Bietak 1987: 43, 1996: 14, 2007: 422). The location of Tell el-Dab<sup>c</sup>a on the Pelusiac branch of the Nile suggests that it may have developed as a port for bringing in Levantine products (Bietak 1987: 41, 43, 1996: 19; Aston 2002: 56-57; Marcus 2007: 164)[27]. Finally, stelae and statuary, particularly an over-life size statue of an Asiatic that has a parallel from the contemporary palace at Ebla, implies that some of the population were higher status administrators probably working for the Egyptian government (Bietak 1996: 19-20; Schiestl 2006).

### 2.2.2. Middle Kingdom in Egypt, Dynasty XIII

Towards the end of the 12th Dynasty problems with the succession seem to have occurred, resulting in the 13th Dynasty being characterized by less powerful and more numerous kings still ruling from the site of Itj-tawy (Table 2.2; von Beckerath 1984: 88-107; Franke 1988b; Quirke 1991; Ryholt 1997: 69-93; Grajetzki 2006: 61-66; Schneider 2006: 175-181). Although some monuments can be attributed to these kings, none were erected by kings of this dynasty in the Delta and after Aya Merneferre‘ no inscribed material is known from the north (Quirke 1991: 126; Schneider 2006: 180). While the kings of the 12th Dynasty appear to have engaged in direct contact with the Levant to procure valuable commodities, those of the 13th Dynasty seem to have lacked the resources to mount any significant

[24] The excavations at Tell el-Dab<sup>c</sup>a have taken place in two main areas, area F/I with strata e/2-3 to a/2 and areas A I-V with strata H to D/2 (see Fig. 2.7).
[25] The chronological divisions and their dates are discussed below.
[26] While the term Middle Bronze Age is a period, it also refers to the Levantine cultural complex during this period.
[27] The idea of the establishment of a trading diaspora finds parallels in the earlier (first quarter of the 2nd Millennium BC) Assyrian trading colony present at Kültepe Kaniš in Anatolia (Özgüç 2003).

expeditions to that region. A stela at Abydos, dated to the 13th Dynasty, names an individual whose title was "keeper of the chamber of Byblos", possibly suggesting that contacts with Byblos were maintained (Grajetzki 2006: 71). Other inscriptions suggest an increased number of people from the Levant were living in Egypt, particularly in the Eastern Nile Delta (Grajetzki 2006: 73, 154-155; Schneider 2003: 207-228).

Table 2.2: Select Kings of the 13th Dynasty, mostly those mentioned in the text (after Ryholt 1997: 73-74)

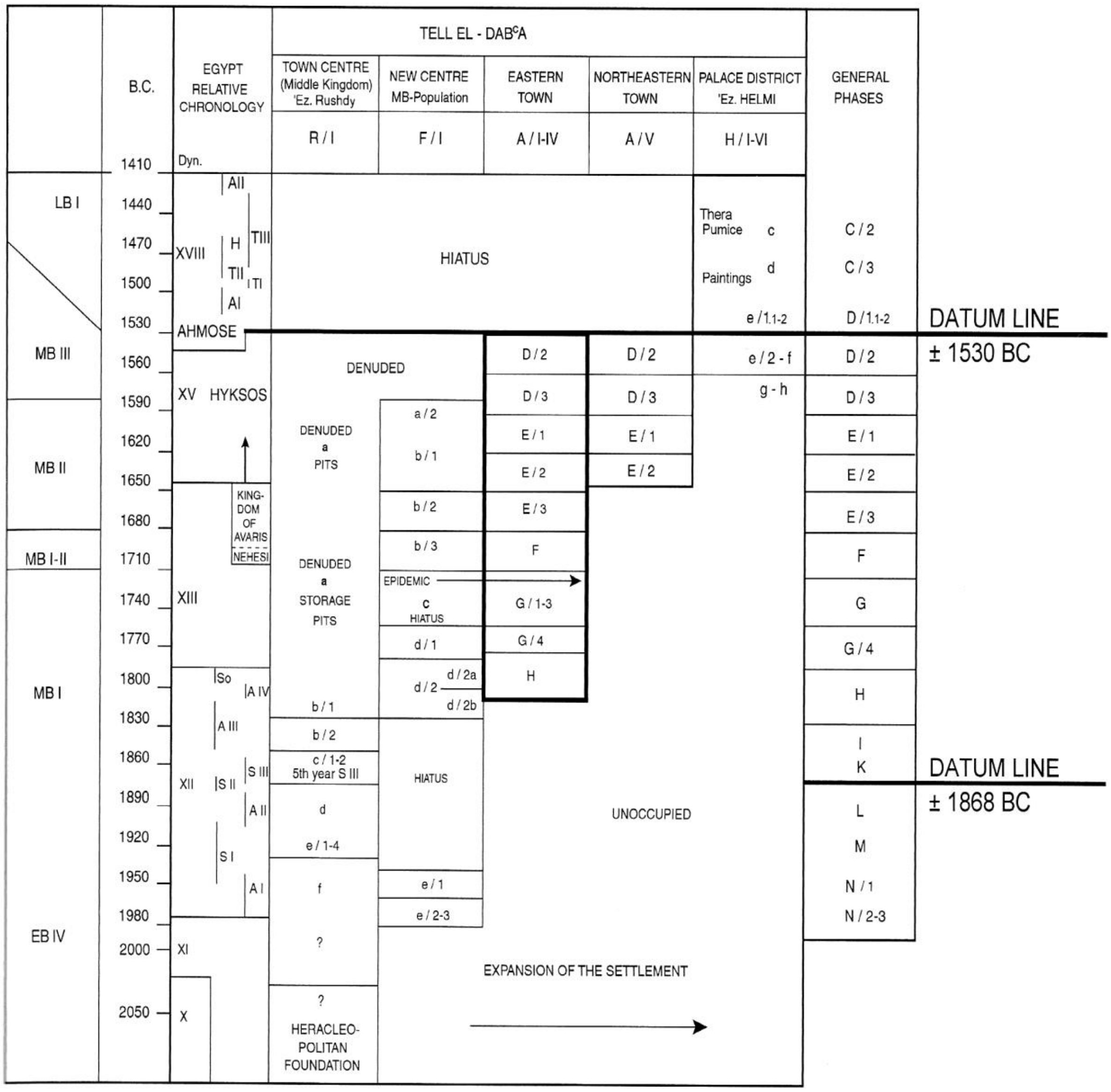
| Nomen | Prenomen |
|---|---|
| Sobkhotep I | Sekhemrekhutawy |
| Amenemhat V | Sekhemkare |
| Siharnedjheritef/ Hornedjheryotef | Hotepibre |
| Sewesekhtawy | Sehotepibre |
| unknown | Nedjemibre |
| Hor | Awibre |
| Neferhotep I | Khasekhemre |
| Sobekhotep IV | Khaneferre |
| Ay | Merneferre |

An Egyptian style palace was built at Tell el-Dab^c^a in the early 13th Dynasty (Stratum G/4=d/1 in Areas A/II and F/I) (Bietak 1996: 21)[28]. The pottery was still dominated by Egyptian types with less than 20% late MB IIA forms (Bietak 1991a: 34-36; Aston 2002). The location of tombs in the garden of the palace is a Levantine tradition, but the tombs themselves were Egyptian (Bietak 1996: 22, 25; Schiestl 2002: 341- 350, 2009). The burials of sheep, goats, and donkeys placed in pits before the tomb entrance is a Mesopotamian custom that is known from Syria and several sites in Palestine such as Akko, Hazor, and Tell el-'Ajjul (Bietak 1996: 25; Bourriau 1997). Ties to Syria were also evident in a haematite cylinder featuring the weather-god, but cut in a way indicative of Egyptian influence (Bietak 1996: 26, 29, 2007: 424). Within a tomb near the palace was found a gold pendant with two dogs facing each other, a style of probable Aegean origin (Schiestl 2000)[29]. Finally, one tomb contained a scarab with the owner's name written in corrupt hieroglyphs, suggesting local manufacture, and signs that seemed to indicate the individual was involved in foreign trade or possibly a prince of Retjenu (Bietak 1996: 26; Martin 1998; Schiestl 2002: 343). These may lend further support to the interpretation that Tell el-Dab^c^a's primary purpose was

[28] Dates are given following the Tell el-Dab^c^a relative chronology for the site, see Fig. 2.8. This is based on Bietak (2007: Fig. 2) and is taken as the most recent opinion on the topic, although future research may change the dates.
[29] Contra Aruz (1993: 44-46).

as a port for conducting trade between Egypt and the Levant, in this case probably the northern Levant as most of the imported MBA ceramics were deriving from this region (Cohen-Weinberger & Goren 2004: 80-81, 93-95)[30].

Fig. 2.8: Schematic Stratigraphy of Tell el-Dab$^{c}$a (Bietak 2002: Fig. 2)




During the mid-13th Dynasty at Tell el-Dab$^{c}$a (Stratum G/1-3=c in Areas A/I and F/I) the site as a whole expands (Bietak 1996: 31). A more egalitarian settlement was built, and the tombs continued to be placed within the settlement (Bietak 1991a: 36-37). While the material culture in the houses was predominantly Egyptian, the funerary objects were mostly

[30] Some examples have close parallels in form and fabric to examples from Tell 'Arqa, a trend that is seen for the later Strata F and E/3 (Kopetzky 2007/2008).

Levantine (Bader in press). As seen in the previous phases, metal objects continued to develop along lines that were similar to changes in the northern Levant (Philip 2006: 232, 236). Egyptian ceramics showed a change in forms and materials, while the late MB IIA ceramics increased from 20% to 40%, although many of these were locally produced (Aston 2002). Of those imported, roughly 80% derived from areas in the northern Levant, while the remaining 20% came from the southern Levant (Cohen-Weinberger & Goren 2004: 80-81, 93-95). The expansion of the settlement and increased amount of locally produced MBA vessels suggests an influx of Levantine peoples during this phase.

The mid-late 13th Dynasty at Tell el- Dab$^{c}$a[31] (Stratum F=b/3 in Areas A/II and F/I) featured a large MBA temple and houses of an Egyptian type, although burials continued to be within the settlement and contained some Levantine grave goods (Bietak 1991a: 38-40). The mud-brick vaulting technique of the tombs was different from the Egyptian methods utilized in the previous phases, and was possibly derived from Mesopotamia (Bietak 1996: 45; Forstner-Müller 2002). The burial of children in amphorae and the placement of servant burials in pits before tomb entrances is also non-Egyptian (Bietak 1989b; 1996: 45). The ceramic repertoire featured 40% MB IIA and early MB IIB types (Aston 2004a). Inscribed doorjambs mentioning a king named Nehesy, probably of the 14th Dynasty, may suggest the presence of independent rulers at Tell el-Dab$^{c}$a at the end of the 13th Dynasty (Bietak 1987: 50, 1996: 40; Ryholt 1997: 94). Additional material inscribed for this king was found at Tell Heboua (Abd el-Maqsoud 1998), Tanis (moved to this site), and Tell el-Muqdam (Bourriau 2000: 190; Ryholt 1997: 103). The appearance of Piriform 1b Tell el-Yahudiyeh jugs, some probably imports and others made at Tell el-Dab$^{c}$a, throughout the Nile Valley and in Nubia around the Second Cataract suggest the site maintained contacts with these areas (Bietak 1989a: 10-13, Figs. 2 and 9)[32].

In the late 13th Dynasty at Tell el-Dab$^{c}$a (Stratum E/3=b/2 in Areas A/II and F/I) another MBA type temple was built, this time surrounded by a cemetery (Bietak 1996: 36, 40). Notably, the houses featured Egyptian material culture, while the burials tended to retain a more Levantine character, particularly in the pottery and weaponry (Bietak 1996: 45). An Egyptian mortuary temple was built although the altar was placed according to Levantine traditions (Bietak 1991a: 40). The presence of an Egyptian temple and Egyptian-style houses

[31] Information regarding the site of Memphis during this period and the Second Intermediate Period is discussed in Chapter 3. Generally, the site revealed only a few MBA imports and some local copies for this period (Bourriau 2000: 196).

[32] For the Tell el-Yahudiya vessel typology, see Bietak (1989a: 8-9, Figs. 1-2) who revised Kaplan's (1980: 15-39) typology based on stratified examples from Tell el-Dab$^{c}$a. A further revision is forthcoming due to the increased numbers of examples from the more recent excavations at the site (Aston 2008).

implies that people carrying an Egyptianized Levantine culture made up a proportion of the population (Bietak 1996: 31, 40). The Egyptian ceramics were similar to those from the previous stratum, and the MB IIB vessel types comprised 40% of the repertoire (Bietak 1991a: 40-41; Aston 2004a). Imported vessels from this and the previous stratum came predominantly from the Northern Levant (60%), while the remainder were from the southern Levant (30%), particularly the Negev (Cohen-Weinberger & Goren 2004: 81, 95-96). Contacts between Tell el-Dab$^{c}$a and Upper Egypt show a reduction with Upper Egyptian Marl A pottery rarely found at the site (Bietak *et al*. 2001: 176)[33]. Furthermore, Piriform 1c Tell el-Yahudiyeh juglets probably made at the Tell el-Dab$^{c}$a were only found in Lower Egypt and in Nubia (Bietak 1989a: 12-13, Figs. 2 and 10). Nevertheless, their distribution within the Levant, Lower Egypt, and Nubia, suggests a trading network existed, with Tell el-Dab$^{c}$a probably basing its economy on this trade (Bietak 1987: 43, 1996: 55). By this time, the site was known by its Egyptian name, Avaris (Czerny 2001).

### 2.2.3. Second Intermediate Period in Egypt

The Second Intermediate Period began when the 13$^{th}$ Dynasty kings abandoned Itj-tawy and moved to Thebes, as the power of the Levantine groups in the Eastern Delta rose (Bourriau 2000:185; 1997)[34]. The 14$^{th}$ Dynasty is attested by inscribed material for four kings in the Eastern Delta, although the number for this dynasty is estimated at 56 rulers, who were succeeded by Hyksos kings of the 15$^{th}$ Dynasty (von Beckerath 1984: 1108-113; Quirke 1991: 126-127; Ryholt 1997: 94-97; Schneider 1998: 99-122; Franke 2008: 273-275)[35]. The names of the 14$^{th}$ Dynasty rulers suggest that they originated from the Levant; seals belonging to the kings have been found at many sites along the southern coastal Levant, particularly at Tell el-‘Ajjul (Ryholt 1997: 105, 115; Fischer & Sadeq 2000: 212). Additional seals in this region belonged to kings’ administrators, also having foreign names, possibly suggesting diplomatic and trade relations with the Levant (Ryholt 1997: 110-111, 130)[36].

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[33] See Nordström and Bourriau (1993: 176-178) for a description of this ceramic fabric.

[34] The first political history of the period was compiled by von Beckerath (1964). For more recent work see Schneider (1998, 2006) and the genealogical work by Bennet (2006: 240-241), which sees an overlap of a few decades between the end of Dynasty XIII and the beginning of the Theban Dynasty. The later is either called the 16$^{th}$ and 17$^{th}$ Dynasties (Ryholt 1997: 151-158) or only the 17$^{th}$ Dynasty making the 16$^{th}$ Dynasty a group of Hyksos vassals (Quirke 1991: 126-127; Schneider 2006: 181-192). Ryholt’s (1997) division will be used in this thesis.

[35] Ryholt (1997: 75-76, 104) believes the 13$^{th}$ and 14$^{th}$ Dynasties were contemporary and both ended with the rise of the 15$^{th}$ Dynasty.

[36] Note that whereas Ryholt (1997:109-110) see seals as having a dominantly administrative function, Ben-Tor (2007a) describes their function as more amuletic. See the review of Ryholt’s work by Ben-Tor *et al*. (1999) and the discussion by Schneider (2006).

This political division was reflected in the material culture of Egypt, particularly in burial practices and pottery, which exhibited a new regionalism. The Delta area was obviously under Levantine influence, but the Memphis-Fayum area developed its own characteristics (Bourriau in press; Bader 2009: 680-707). In middle Egypt, there appears a mix of the material culture from the Memphis-Fayum area and that at Thebes (Bourriau in press). These changes did not occur all at once, but reflect the early break of Upper and Middle Egypt from the Memphis-Fayum area, probably in the mid-13th Dynasty. The traditions developed in the south spread northwards by the end of the Second Intermediate Period (Bourriau 1997).

The textual and epigraphic evidence, mostly from scarabs, suggests the Hyksos 15th Dynasty consisted of six rulers that controlled the northern half of Egypt for roughly 100 years (Table 2.3; Ryholt 1997: 118-130; von Beckerath 1997: 137; Schneider 1998: 31-49, 57-75, 2006: 192-195; Bourriau 2000: 193; Bietak 2001: 138-140, 2007a: 431)[37]. Three of the kings, Yaqub-her, Khyan, and Apepi, adopted prenomens from 13th Dynasty Egyptian kings suggesting they were emulating these rulers at least in terms of royal protocol (Redford 1992: 116; Bietak 2007a: 431).

Contacts with the Levant are illustrated by the numerous imported design scarabs that were probably manufactured in Palestine (Ben-Tor 2007a: 185, 191, 2009: 3). Initially these Palestinian scarabs were similar to late Middle Kingdom examples, but by the Second Intermediate Period they had developed hybrid Egyptian/Levantine motifs and were found throughout the Nile Valley (Ben-Tor 2004: 38, 2009: 4). Further, these scarabs appear to have influenced the royal-name and private-name scarabs being manufactured at Tell el-Dab$^{c}$a (Mlinar 2004). Additional evidence for Levantine influence is a dagger found at Saqqara in the tomb of Queen Apu-it (Daressy 1906: 116, Plate VII; Aruz 1993: 40). It contains an inscription for the Hyksos king Apophis, and shows an animal hunt scene similar to those found on Syrian seals. Overall, the MBA culture appears restricted to the Delta region with only some imported vessels, such as Canaanite jars and Tell el-Yahudiyeh ware, and scarabs found elsewhere to indicate contact with Levantine peoples in the Delta.

[37] For early discussions of the Hyksos see Engberg (1939) and Van Seters (1966).

Table 2.3: Kings of the 15th Dynasty (after Bietak 2007a: Table 29.1)

| Nomen | Prenomen |
|---|---|
| Seker-her | None |
| Yaqub-her | Meruserra |
| Khyan | Seuserenra |
| Yanassi-iden | None |
| Apepi (Apophis) | Aauserra |
| Khamudi | None |

Evidence from Tell el-Dab^c^a suggests that trade with the Levant declined from this period onwards (Bietak 1987: 52, 1996: 35, 59). Political instability in the Levant may have been the cause and may also have encouraged people to move outside of the area due to the threat from Babylon (see below). Tell el-Dab^c^a (Stratum E/2=b/1 in Areas A/II, A/V, and F/I) shows an influx of people with an Egyptianized MBA culture (Bietak 2007a: 428). The houses are predominantly Egyptian with Levantine traits such as courtyard cemeteries with donkey sacrifices, children buried in amphorae, and the continuation of the MBA type temples (Bietak 1991a: 4). Additionally, the site expands significantly in Stratum E/2 and the local Egyptian pottery begins to show a change (Bietak *et al*. 2001: 172-175). The distribution of the mostly locally produced Tell el-Yahudiyeh juglets suggests a further reduction of contacts with Upper Egypt, as vessels are found outside the Delta as far south as Kerma, but rarely in Upper Egypt (Bietak 1987: 55, 1989a: 15, Figs. 2, 11, 13-14; Bietak *et al*. 2001: 175). These vessels were now exported to the Levant, particularly southern Palestine, and Cyprus (Artzy & Asaro 1979; Bietak 1987: 52, 55). Imported vessels although fewer in number were coming mostly from the northern Levant (Kopetzky 2004: 276; Cohen-Weinberger & Goren 2004: 81, 96-97). Material culture featuring a mixture of Egyptian, MB IIB, and local developments, has also been found at the eastern Delta sites of Tell el-Maskhuta (Holladay 1982, 1997: 188-198, Holladay 2001a: 50-51; Redmount 1995a and b), Tell el-Retabah (Holladay 1997: 192-194), and Tell el-Yahudiyeh (Petrie 1906; Weinstein 1997: 368; Holladay 2001b: 527).

In the 15th Dynasty (Stratum E/1=b/1-a/2 in Areas A/II, A/V, and F/I), the site continued to expand, and the MBA temples remained in use (Bietak 1991a: 41). The Egyptian pottery was now very different from the 13th Dynasty types, while most of the MBA shapes (roughly 40% of the assemblage) were made locally. These included some Canaanite jars, although others were imported (Bietak 1991a: 42-43; Aston 2004a). The fewer imported vessels were mostly from the Northern Levant with a smaller proportion from the southern

Levant (Cohen-Weinberger & Goren 2004: 81, 96-98). The metal weapon types were more closely affiliated with those in southern Palestine, while different forms appear in the northern Levant and Cyprus (Philip 2006: 232).

In the next phase (Stratum D/3=a/2 in Areas A/I, A/IV, A/V, and F/I), the temples remained in use but the settlement became more compact and extended over the earlier cemeteries (Bietak 1991a: 43). The new types of Egyptian pottery from the preceding phase continued, while the MBA types changed (Bietak 1991a: 43-44; Aston 2004a). Imported amphorae were found alongside those produced with Nile and Marl (limestone) clay (Bietak 1991a: 45; Aston 2004a: 240-241)[38]. The ceramic evidence also reflects a decline of trade relations with Nubia, Upper Egypt, and Cyprus. For example, Marl C imports, probably from the Memphis/Fayum area, were found at Tell el-Dab$^{c}$a from the early 12$^{th}$ Dynasty, but at the beginning of the 15$^{th}$ Dynasty they appeared only rarely (Bader 2001 and 2002; Bietak *et al.* 2001: 176)[39]. The increased influence of the Thebans may have affected trade routes to the south, which resulted in less economic activity for the Hyksos and may have contributed to their decline (Bietak 1987: 55; 2007: 431).

In the following phase, a large fortress and a watch tower were built along with an enormous enclosure wall (Stratum D/2 in Areas A/II, A/IV, and A/V); suggesting the Hyksos felt the need to fortify their city against some perceived threat (Bietak 1996: 63-64). The settlement became more compacted in certain areas (A/II) and large tombs of Egyptian style appeared (Bietak 1991a: 45-46). The Egyptian pottery types seen in the previous phase continued, while the almost entirely locally produced MB IIC forms comprised 30% of the assemblage (Bietak 1991a: 46; Aston 2004a). The locally produced Biconical Tell el-Yahudiyeh juglets were found mostly in the eastern Delta, Lower Nubia, and Cyprus (Bietak 1989a: 15, Figs. 2, 13-14). The late Second Intermediate Period cultural complex at Tell el-Dab$^{c}$a was also discovered at several other sites in the Delta including Tell Farasha (Yacoub 1983), Tell el-Yahudiya (Petrie 1906; Weinstein 1997: 368; Holladay 2001b: 527), Tell el-Maskhuta (Holladay 1982, 1997: 188-198, 2001a: 50-51; Redmount 1995a and b), Tell el-Retabah (Holladay 1997: 192-194), and Tell Heboua (Abd el-Maqsoud 1998). Additional sites featuring both MBA and Egyptian cultural aspects, along with local developments, were identified both to the east and west of the Pelusiac branch of the Nile (van den Brink *et al.* 1987: 19, 23-24).

[38] Marl clay Canaanite jars were also found at Tell el-Maskhuta (Redmount 1989: 847, 851).
[39] See Nordström and Bourriau (1993: 175-181) for a description of the Marl C fabric.

Meanwhile, the Theban area was under the control of perhaps 15 kings constituting Dynasty XVI and 10 kings comprising the 17th Dynasty (Table 2.4; von Beckerath 1984: 116-131; Ryholt 1997: 157, 171; Schneider 1998: 123-145; Polz 2007; Franke 2008: 275-280). The territory of the 16th Dynasty appears to have extended from Abydos in the north to Elephantine in the south (Ryholt 1997: 159; Franke 2008: 176)[40]. The 17th Dynasty controlled at least the area from Cusae in the north to Elephantine in the south (Ryholt 1997: 171-172). This political situation is described by the Egyptians on a stela, called Kamose stela I, in which the Hyksos are stated as ruling the territory to the north of Cusae (Bourriau 2000: 195). In fact, the sites of Mostagedda and Rifeh, 30 miles south of Cusae, reveal two distinct material cultural patterns (Bourriau 1999: 44-46). The site of Mostagedda featured pottery similar to that in Upper Egypt in rich Nubian burials. The material from the Nubian burials at Rifeh had greater connections to that from the Memphis/Fayum area. This confirms the impression in the Kamose stela that the area was a border, with one side controlled by Nubians tied to the north (Rifeh), and the other side secured by Nubians allied to the south (Mostagedda). The border probably existed as early as the beginning of the 13th Dynasty (Bourriau 2000: 203). Further, the suggested contacts with the Kerma Nubians mentioned in the stela are borne out by the presence of sealings and scarabs of Hyksos kings found at Uronarti and Kerma, along with Tell el-Yahudiyeh juglets from Buhen and Aniba. The site of Buhen also contained Egyptian ceramic material similar to that from the Memphis-Fayum region, suggesting contact with territory under Hyksos influence (Bourriau 1999: 47)[41]. However, towards the end of the Second Intermediate Period, pottery of the style of Upper Egypt appears at Buhen, Mirgissa, and Askut, and the presence of Kerma Nubians in Upper Egypt is stronger, confirming the break in contact with the Delta as the power of the Thebans grew (Bourriau 1991c). The explusion of the Hyksos kings from Egypt by the Thebans heralded the end of the Second Intermediate Period.

[40] Ryholt's (1997: 163-166) suggestion of a dynasty at Abydos has largely been rejected, see Ben-Tor *et al.* (1999: 49-52) and Franke (2008: 277-278).

[41] Unfortunately, linking the material culture remains to particular levels at Buhen is difficult from the original publication (Emery *et al.* 1979). Some revisions were made by Smith (1995: 110-122).

Table 2.4: Kings of the 17th Dynasty (after Ryholt 1997: 171)

| Nomen | Prenomen |
|---|---|
| Rahotep | Sekhemrewahkhaw |
| Sobkemsaf I | Sekhemreshedtawy |
| Antef VI | Sekhemrewepmaat |
| Antef VII | Nubkheperre |
| Antef VIII | Sekhemreherhermaat |
| Sobkemsaf II | Sekhemrewadjkhaw |
| Siamun? | Senakhtenre |
| Tao | Seqenenre |
| Kamose | Wadjkheperre |

## *2.3. The Middle Bronze Age in the Levant*

### 2.3.1. Chronological considerations

Within Near Eastern archaeology, debates have centred not only on the terminology used for the Middle Bronze Age but also on absolute dates. The designations for the MBA were first proposed by Albright (1936-1937: 13-16, 23-25, 58-60) as Middle Bronze IIA, IIB, and IIC, with the period between the Early Bronze Age (EBA) and MBA being designated Middle Bronze I (see also Mazar 1968: 67-69, 97). However, other scholars saw significant cultural differences between the main EBA and MBA and proposed other designations for this period. Kenyon's (1960: 2-3, 180; 1979) system began with Intermediate EB-MB, followed by MB II and MB III. Kochavi (1975: 38-40) designated the period between the EBA and MBA Intermediate Bronze Age, followed by MB IIA and MB IIB[42]. Dever (1976) used MB IIA, MB IIB, and MB IIC for the main periods, but EB IV/MB I for the transition from the EBA to the MBA. Gerstenblith (1983: 2-3) examined the archaeological evidence at the beginning of the MBA and determined that the MB II and MB III system was appropriate. However, for the current study, the MB I, MB IIA, MB IIB, and MB IIC divisions are employed in order to corresponding with the system used at Tell el-Dab$^{c}$a (see below).

Each of the above systems proposed their own dates for the periods based largely on the material described above and below reflecting connections between Egypt and the Levant (Table 2.5; Albright 1966; Kenyon 1979: 145-147, 155, 177; Dever 1985: 75-79). This is due to the fact that Palestine has only a few internal dates for an absolute chronology and

[42] Kenyon (1979: 155) and Kochavi (1975: 38-39) see little break in material culture from MB IIB to MB IIC (all of MB II for Kenyon), and thus omit a MB IIC phase, the issue is discussed further by Bienkowski (1989) who supports this opinion.

therefore must tie in dates with either the Egyptian or Mesopotamian chronologies[43]. Thus, the discovery of an inscribed Egyptian object is utilized to date the strata or level from which it came. However, this is problematic due to issues of context and the certainty with which the object arrived and was deposited in a short period of time. Gerstenblith (1983: 102-108) proposed revised dates for the MB I (ca. 2000/1950 to ca. 1750 BC). These dates are similar to those suggested by Dever (1991) (Table 2.6). These dates have been further revised by Dever (1992) and constitute the "high" chronology (Table 2.6). The "middle" chronology was advocated by Weinstein (1992) who saw the beginning of MB IIA around ca. 1900 BC and lasting until ca. 1750/1700 BC[44].

Table 2.5: Middle Bronze Age Terminologies

| Albright (1936/7) | Kenyon (1979) | Kochavi (1975) | Dever (1976) |
|---|---|---|---|
| MB I (2100-1900) | Intermediate EB-MBI (ca. 2300-1900) | Intermediate Bronze Age | EB IV/MB I (2200-1950) |
| MB II A (1900-1750) | MB I (ca. 1900-1850 | MB IIA | MB II A (1950-1800) |
| MB II B (1750-1650) | MB II (ca. 1850-1567) | MB IIB | MB II B |
| MB II C (1650-1550/1500) | | | MB II C |

Table 2.6: Revised dates established by Dever (1991, 1992: Fig. 1) and Weinstein (1992: Table 1) for the MBA

| Period | Dever (1991) | Dever (1992) | Weinstein (1992) |
|---|---|---|---|
| EB IV/MB I | ca. 2000/1950-1750 | ca. 2300 – 2000 | |
| MB I/MB IIA | ca. 1950-1825 | ca. 2000/1950 – 1775 | ca. 1900/1875 – 1740/1730 |
| MB I-II/MB IIA-B | ca. 1825-1775 | ca. 1775 – 1750 | ca. 1740/1730 – 1720 – 1710 |
| MB II/ MB IIB | ca. 1775-1675 | ca. 1750 – 1650 | ca. 1720/1710 – 1625 |
| MB II-III/MB IIB-C | ca. 1675-1625 | | |
| MB III/ MB IIC | ca. 1625-1525 | ca. 1650 – 1500 | |

[43] For both of these chronologies the absolute dates of the periods are debated; there is a high, middle, low, and ultra-low chronology for Mesopotamia (see the latest works in Armstrong and Warburton (2000) and Hunger & Pruzsinszky (2004) and a high and low chronology for the Middle Kingdom (see below).
[44] Both Dever (1992: 2) and Weinstein (1992: 38 ff.) use the Egyptian "high" chronology for the Middle Kingdom, see below.

The presence of MBA material culture at the site of Tell el-Dab$^{c}$a provided a unique opportunity to correlate the Egyptian chronology to the Syro-Palestinian chronology (Bietak 1991a: 47-57). Bietak's "low" chronology[45] was based on excavated material such as Egyptian inscriptions belonging to known individuals, scarabs, and ceramic types assignable to a stratified sequence (Bietak 2002). The changing dimensions of hemispherical cups over time allows for synchronisms between those at Tell el-Dab$^{c}$a and those from the complexes at Dahshur associated with royal monuments. This provided relative dates for Stratum H=d/2 from the later reign of Amenemhat III until the reigns of Amenemhat IV and Nofrusobek (Fig. 2.8 and Table 2.7; Bietak 1991a: 49-51, 1984: 480-482). This association is supported by the comparability of beer bottles excavated from Stratum H=d/2 and those from Dahshur (Szafranski 2002: 365). Further similarities dated Stratum G/4=d/1 at Tell el-Dab$^{c}$a to the beginning of the 13$^{th}$ Dynasty (Szafranski 2002: 365). This meant that the MB IIA remains from these strata should date to the end of the 12$^{th}$ Dynasty and start of the 13$^{th}$ Dynasty, providing a date for this period. Other strata were similarly dated and the comparison of Levantine objects (especially the types of Tell el-Yahudiyeh ware) within these strata to material from sites in Palestine assisted in determining chronological correspondences and dates (Table 2.7). Despite some disagreement (Dever 1991, 1992; Weinstein 1992a, 1995), the chronological scheme has remained relevant for the Levant and has been further supported by synchronisms with the site of Ashkelon (Bietak 2002; Bietak *et al*. 2008).

Table 2.7: Dates of strata at Tell el-Dab$^{c}$a in relation to Egyptian and Levantine chronologies (Bietak *et al*. 2001: Fig. 1)[46]

| **Stratum** | **Egyptian Chronology** | **Levantine Chronology** | **Dates** |
|---|---|---|---|
| H=d/2 | Late 12$^{th}$ Dynasty – Early 13$^{th}$ Dynasty | MB IIA | ca. 1820-1760 |
| G/4=d/1 | Early 13$^{th}$ Dynasty | MB IIA | ca. 1760-1755 |
| G/1-3=c | 13$^{th}$ Dynasty | MB IIA | ca. 1755-1710 |
| F=b/3 | 13$^{th}$ Dynasty | MB IIA/IIB | ca. 1710-1680 |
| E/3=b/2 | Late 13$^{th}$ Dynasty | MB IIB | ca. 1680-1650 |
| E/2=b/1 | Early SIP | MB IIB | ca. 1650-1620 |
| E/1=b/1-a/2 | SIP | MB IIB | ca. 1620-1590 |
| D/3=a/2 | SIP | MB IIC | ca. 1590-1560 |
| D/2 | Late SIP | MB IIC | ca. 1560-1530 |

[45] Weinstein's (1992) Middle Chronology is similar, although the transitional MB IIA-B period is placed 25 years higher in the this system.
[46] While the site lacks the first part of MB IIA, Bietak (2002: 38-42, 2007b) dates the beginning of the MBA at ca. 1920/1900 BC.

However, a complicating factor is the uncertainty in the Egyptian chronological system (von Beckerath 1997; Kitchen 2000; Hornung *et al*. 2006). There exists a “high” chronology (Kitchen 1987) and “low” chronology (Krauss 1985; Franke 1988a: 264-272) for the Middle Kingdom. This is due to several issues; 1) the length of reign for some kings is not established; 2) the number and order of kings, particularly in the 13th and 16th Dynasties, is still not certain; 3) the sources based on Manetho are not always in agreement and the Turin kinglist is in poor condition for the Second Intermediate Period; and 4) the astronomical data provide various dates depending on where the sighting of the star Sirus was made (Kitchen 1987: 42-47; Ryholt 1997: 10-18; Hornung *et al*. 2006). Recent work on the genealogy of the high officials in the Second Intermediate Period supports a “high” Middle Kingdom chronology, 1872 or 1866 BC for year 7 of Senusret III (sighting of Sirius), and a “low” chronology for the New Kingdom, 1539 BC for beginning of Ahmose’s reign (Bennet 2006). The high chronology would place the beginning of the 12th Dynasty at ca. 1980/1970 BC and the end ca. 1790 BC (Kitchen 2006: 303). Finally, most evidence still seems to support ending the Second Intermediate Period and beginning the New Kingdom around 1540/30 BC (Kitchen 2006: 303; Bietak & Höflmayer 2007: 14).

### 2.3.2. The Middle Bronze Age in the Levant

The period between the EBA and MBA in the southern Levant was characterized by groups of semi-sedentary people. Excavations of the many burials from this period do not reveal any contacts with Egypt (Rainey 1994: 82, 2006: 280). At the beginning of the MBA, due either to outside apparently northern influences, seen in new styles of pottery and weaponry, or internal forces, or both, cities were once again established (Dever 1976; Tubb 1983; Dever 1992: 2; Rainey 2006: 282). Most sites feature an initial smaller unfortified settlement (Rainey 2006: 282; Gophna & Portugali 1988: 12, 17, 19-20). The MBA cities appeared first on the northern coast and then were gradually established in the interior along the major wadis and in the Jordan Valley, until towns in southern Palestine were also founded (Cohen 2002: 107-128; Gophna and Portugali 1988: 17-20). Their placement along the coast may have been due to a desire to carry out trade regionally and internationally.

However, this increased contact was apparently not without inherent risks to the urban populations. While, some towns had begun to build impressive fortifications at the end of MB IIA, by MB IIB most cities were fortified (Dever 1976: 16, 1985: 71-74; Oren 1997: 255-259; Cohen 2002: 109-123). Throughout the MB IIB and MB IIC periods, towns flourished and enlarged. Undoubtedly, these cities engaged in intense interactions, as shown at Ashkelon (Stager 2002), and probably occasionally fought each other, necessitating fortifications. However, there are no textual sources from this region during this period to provide specifics on these political issues. Many sites show destruction and abandonment at the end of the MBA.

In the northern Levant at the end of the EBA, most cities appear to continue, although on a reduced scale. By the end of the 20th century BC powerful states arose in Syria, particularly Yamkhad, with its capital at Aleppo, and Mari on the Upper Euphrates (Klengel 1992: 49-64; Van De Mieroop 2007: 103-105)[47]. Yamkhad carried out a lucrative trade between the Eastern Mediterranean and the polities in Mesopotamia, including Babylon and Assyria, via the trading centre of Emar (van Koppen 2007: 367-370). The rulers of Alalakh and Ugarit appear to have had family ties with the kings of Yamkhad. From the textual evidence, Ugarit and Mari were important for moving tin within the Northern Levant, a key component of bronze, while at the latter city references are made to copper from Alashiya, commonly held to be Cyprus (Malamat 1971: 32-33, 38; Yon 2006: 18)[48]. Mari also played a pivotal role in trade with Babylon, Yamkhad, Alalakh, Ebla, Qatna, and Hazor (Malamat 1971; Bonechi 1992). Mediterranean goods were brought to Mari through the city of Qatna. On the coast was the city-state of Amurrum that was probably responsible for the movement of goods from the Mediterranean.

By the 17th century BC, Qatna and Mari had a close diplomatic relationship and were allied against Yamkhad, which was the dominant power in the region (Klengel 1992: 65-70). However, the destruction of Mari by the king of Babylon, Hammurabi, in ca. 1664 BC (Gasche *et al*. 1998: 90; Ben-Tor 2005: 55) resulted in most of the trade between the Mediterranean and Syria being controlled by Yamkhad. Within initially Qatna, and then Yamkhad's sphere, was the city of Hazor that provided a location for goods moving between Palestine and the northern Levant via the Jordan Valley. The city also had contacts with Babylon (van Koppen 2007: 370-372). By the end of the MBA, Ugarit saw a decline while Alalakh was attacked by the Hittite king Hattusili I in the mid-16th century BC (Klengel 1992: 44, 77-78, 80-83; Van De Mieroop 2007: 121). Shortly thereafter, Aleppo was destroyed by his successor Mursili I (Klengel 1992: 64). The latter event finally ended the powerful kingdom of Yamkhad, and in fact Mursili I also sacked Babylon in ca. 1507 BC

[47] This discussion utilizes the Low/Ultra-low Chronology for Mesopotamia based on recent research on the topic, see Gasche *et al*. (1998), Zeeb (2004), Ben-Tor (2005). The results of a conference on Mesopotamian chronology (Jan. 2010) also support the Low Chronology (this information was provided by M. Bietak).

[48] Little documentation or archaeological remains have been uncovered for MBA Ugarit (Yon 2006: 18). The work by Goren *et al*. (2004: 70-75) suggested Alashiya should be associated with southern coastal Cyprus.

(Zeeb 2004: 92)[49]. Hazor as well appears to have prospered until destroyed at the end of the MBA. Due to the fall of Yamkhad, people known as Hurrians began to move into the Levant. These events lead to the slow decline of the northern Levant and eventually changes in the archaeological record that denoted the end of the MBA.

### 2.3.3. Contacts with Egypt during the MB IIA

The apparent emphasis on trade in this political situation would have inevitably resulted in contact with Egypt. During the MB IIA, the evidence for contact with Egypt derives from scarabs, cylinder seals, and inscribed objects[50]. The Montet jar from Byblos contained scarabs and numerous other Egyptian objects of various date, but the latest objects attest to an early 12th Dynasty date (Montet 1928: 111-125; Giveon 1987: 24; Ben-Tor 1998: 12)[51]. The cartouche of Senusret I was found on a limestone fragment also at Byblos (Jidejian 1971: 25; Ward 1971: 68, n. 272) and a stone vessel from Qatna (Roccati 2002). Scarabs inscribed with the name of Senusret I are the most numerous, especially when compared to later kings, and were found at Megiddo and Beth Shean (one in a LBA context). Four impressions from a seal of Senusret I were found at Gezer (Giveon 1987: 25)[52]. A carnelian bead inscribed for this king was discovered at Ugarit (Yon 2006: 16). Additional scarabs are known from Tomb 66 at Ruweisé, Kafer Garra, Lachish, and Tell el-‘Ajjul (Giveon 1987: 28)[53].

Although an inscription from Egypt provides evidence for Amenemhat II’s activities in the Levant, only one possible scarab of this king is known, from the site of Megiddo (Giveon 1987: 29). A bone cylinder inscribed for Amenemhat II was discovered at Byblos (Jidejian 1971: 25). Senusret II is attested from scarabs at Ruweisé (Tomb 73), Beth Shean, Megiddo, Lachish, Jericho, Akko, Amman, Kafer Garra, Shechem, Tell el-‘Ajjul, and Gaza (Guigues 1938: 57-59; Tufnell and Ward 1966: 223; Giveon 1987: 25, 29-30). Once again,

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49 However, Gasche *et al*. (1998) dates the fall of Babylon to ca. 1499 BC on the Ultra Low Chronology.

50 Middle Kingdom Egyptian statuary of kings and nobles found in the Levant is likely to have arrived during the 15th Dynasty (Weinstein 1974: 56; Helck 1976), and probably relates to contacts between the Hyksos and the Levant in the second half of the MBA (see below).

51 Montet (1928: 129) dated the jar to the end of 6th Dynasty as it lacked inscribed Middle Kingdom material. Tufnell & Ward (1966: 227) dated it to between 2130 and 2040 BC. The date in the early 12th Dynasty is based on a revised typology for the scarabs (Ben-Tor 1998).

52 No scarabs or seals of Amenemhat I have been found in the Levant (Giveon 1987: 25). Ward (1971: 68) stated scarabs attributed to Senusret I were mostly dated after he reigned and thus not indicative of foreign contact during the period. Ben-Tor (2007b: 17) dates the beginning of production of royal name scarabs to the end of the 12th Dynasty, suggesting the earlier examples are reissues.

53 Design scarabs dated to this period were also found in Palestine, but there is still debate on their contexts and dates. For a discussion of some of these scarabs and other potential Egyptian artifacts in Palestine during the early MBA see Weinstein (1975).

most of these contexts are uncertain, surface finds, or the object was found in LBA levels. Further, the possibility exists that these scarabs were produced during the late 12th Dynasty and are not contemporary with the early Middle Kingdom (Ben-Tor 2007b: 17).

Fewer objects inscribed for kings of the latter half of the 12th Dynasty are known from the Levant. Only a single scarab found at Gezer has the name of Senusret III (Giveon 1987: 26). A scarab from Tell Jemmeh was inscribed for both Senusret III and Amenemhat III (Giveon 1987: 26, 30). For the latter king, objects include an inscribed serpentinite vase from the Royal Tomb at Qatna (Ahrens 2006)[54], an obsidian vase found in Royal Tomb I at Byblos (Montet 1928: 153), and a scarab from Tell el-'Ajjul (Giveon 1987: 26, 30). For Amenemhat IV, an obsidian box with his cartouches was found at Byblos (Montet 1928: 157)[55].

Objects in the Levant inscribed for early 13th Dynasty kings (Table 2.2) include a silver cylinder of Hotepibre (Hornedjheryotef) [56] as part of a unique Egyptian limestone mace found at Ebla (Matthiae 1997: 397-398; Scandone-Matthaie 1997: 418-419)[57]. This site also produced a number of ivory inlays depicting Egyptian gods that were probably produced locally (Matthaie 1997: 406-407; Scandone-Matthaie 1997: 420-425). Seals inscribed for Hotepibre and Nedjemibre are dated to Dynasty XIII based on their style, which is similar to the Hyksos-style (Giveon 1987: 32; Ryholt 1997: 73)[58]. A cylinder-seal from Byblos has the name of King Sewesekhtawy next to that of a Byblos king (Helck 1983: 19; Ryholt 1997: 73, 87). From the same site, is a relief fragment showing King Neferhotep I next to the 'governor of Byblos' (Montet 1928: 278; Ryholt 1997: 87; Grajetzki 2006: 71). Seals of Neferhotep I were found at Byblos, Fassuts (near Tel Kabri), and Tell el-'Ajjul (Ryholt 1997: 85).

The discovery of Egyptian Marl storage jars at several sites in the Levant indicates the import of goods from Egypt. A number of sherds from Marl vessels dated to the late 12th Dynasty and early 13th Dynasty were found at Sidon (Bader 2003; Forstner-Müller & Kopetzky 2006; Forstner-Müller *et al*. 2006; Griffiths & Ownby 2006)[59]. These mostly Marl

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[54] Other stone vessels were also found in the Royal Tomb at Qatna that are unscribed but of Middle Kingdom date (Ahrens 2006: 16), while additional stone vessels of this date were found at a few sites along the Levantine coast (Sparks 1998: 509).

[55] Montet (1928: 159) also found a grey stone vase with the name Amenemhat in Royal Tomb II.

[56] Ryholt's (1997: 84 ff) assertation that the mace was made locally has not been supported, but see Lilyquist (1993: 46) who also suggests the object was produced in the Levant.

[57] A statue of King Hetep-ib-re' 'Amu-sa-Hornedjheryotef, who is associated with the last ruler of the 12th Dynasty, Queen Sobeknofru, was uncovered at Tell el-Dab$^{c}$a (Bietak 1996: 30). Some debate exists over the translation of 'Amu-sa as "the Asiatic's son", see Ryholt (1998: 1-2).

[58] Ryholt (1997: 40, 51-52) ascribes the scarab of Hotepibre to the 15th Dynasty.

[59] Sidon not only had an excellent port, but the site controlled the route to the southern Beqa'a and thus access to inland Lebanon (Doumet-Serhal 2008: 3).

C jars probably came from near the 12th Dynasty capital (Nordström and Bourriau 1993: 179-181). A jar of the probable Upper Egyptian Marl A4 fabric was also found (Nordström and Bourriau 1993: 177-178). Similar examples of Middle Kingdom Marl vessels are known from Tell ‘Arqa, (Kopetzky 2007/2008: 23), Byblos (Dunand 1964: 32), and Akko (Marcus *et al*. 2008a: 215 ff). The site of Tel Ifshar also contained Egyptian pottery in MB IIA contexts (Marcus *et al*. 2008a). The jar fragments were produced in Marl C, Marl A3, Marl A4, and Marl DAN E3[60] fabrics. The three latter fabrics were probably derived from Upper Egypt. The site of Ashkelon also imported Marl vessels during this period (Stager 2002: 359; Bietak *et al*. 2008: 52). Early 13th Dynasty sealings were discovered in a moat from this site as well, and suggest a more significant Egyptian presence (Stager 2002: 353; Bietak *et al*. 2008: 58). These objects provide evidence for the resumption of interaction between Egypt and the Levant during the MB IIA.

### 2.3.4. Contacts with Egypt during the MB IIB

Contact continued between Egypt and the Levant in the MB IIB. Non-royal scarabs of the mid to late-13th Dynasty were found at Byblos, Akko, Megiddo, Tel Aphek, Jericho, Gezer, ᶜAin Samiya, Beth Shemesh, Tell el-Farᶜa, Lachish, Shechem, and Tell el-‘Ajjul (Giveon 1987: 32; Ben-Tor 1994: 12-15). Several design scarabs found in tombs at Beirut have been attributed to this period (Ward 1993-1994: 212-215). Some Middle Kingdom scarabs were found at Ugarit (Schaffer 1949: Fig. 23). Once again, there is the possibility that these scarabs have a funerary/amuletic function and therefore do not reflect Egyptian administrative activity (Ben-Tor 1994: 8). Only at Byblos are they present in large numbers, possibly indicating continued contacts with this site during Dynasty XIII, while they are rare in Palestine.

Further evidence for continued relationships between Egypt and Byblos comes from hieroglyphic inscriptions in the royal tombs, including Egyptian titles for the Byblian kings, hymns, epithets, and the names of Egyptian gods (Montet 1928: 274-279; Ryholt 1997: 86-89). Most of these objects were locally produced, including the seals of the kings (Ryholt 1997: 89). During the late 12th Dynasty and into the 13th, the kings of Byblos called themselves *h3ty-‘* ‘governor’ of Byblos; later they adopted the term ‘ruler of rulers’ that then became ‘ruler of foreign/mountainous lands’ or *hk3w h3swt* (Montet 1928: 196, 208, 277; Ryholt 1997: 86-89). A prince of Kumidi (Kamid el-Loz) also seems to have adopted this title (Edel 1983), while a prince of Ugarit was called *h3ty-‘* (Martin 1999). Later Byblos

[60] This fabric was identified at Draᶜ Abu el-Naga near Thebes by Seiler (2005: 35).

princes, such as those in Tomb IV, still had their names written in hieroglyphs in cartouches and were called ‘hereditary prince’ (Montet 1928: 279). However, no Egyptian objects were found in the tombs of possible Second Intermediate Period date (Montet 1928: 279).

The distribution of Egyptian stone vessels over a wider area in this period than in the previous one, including inland areas, implies increased trade between Egypt and the Levant (Sparks 1998: 509). Additionally, Marl C jars from Egypt were found at Byblos (Montet 1928: 199, Plates CXVI and CXVIII)[61] and Ashkelon (Stager 2002: 359; Bietak *et al*. 2008: 52) in this period. This confirms other evidence suggesting cities in the southern Levant were becoming more involved in the movement of goods.

### 2.3.5. Contacts with Egypt during the MB IIC

During the MB IIC there is less evidence for Egyptian materials reaching the Levant. Tell el-‘Ajjul has produced the largest collection of Egyptian royal and design scarabs for this period (Ben-Tor 2009: 4), while there are almost no scarabs in the northern Levant (Ben-Tor 2007a: 185, 191, 2009: 3). Further, many of the scarabs from this date in Palestine are clearly local productions combining Egyptian motifs and Levantine designs derived from Syrian cylinder seals (Ben-Tor 2009: 4). Surprisingly, only four seals of 15$^{th}$ Dynasty kings have been found in the Levant: at Gezer, Tel Zafit and Jericho (Ryholt 1997: 130). The discovery at Knossos of an alabaster vessel inscribed with the cartouche of the Hyksos king Khyan, and a similarly inscribed obsidian vessel at the Hittite capital of Bogazköy, have been used to suggest political relationships between the Hyksos and far flung empires (Helck 1983: 54-55; Mellink 1993). However, the means by which these vessels arrived at the sites are difficult to reconstruct.

The appearance of Middle Kingdom royal and private statuary in the Levant is probably related to the Hyksos rulers sending these objects to their compatriots in this region, possibly as part of the system of gift exchange known between rulers in the Levant (Liverani 1990: 211-215; Ryholt 1997: 139, 143-144)[62]. Sites with royal statuary include Ugarit (statue of Khunumet and sphinx of Amenemhat III; Schaeffer 1939: 21, Plate III. 2, Yon 2006: 16), Aleppo (sphinx of Amenemhat III; Porter & Moss 1952: 395), Beirut (sphinx of Amenemhat

[61] Dated by Kopetzky (2007/2008: 26) to early MB IIB.

[62] The discovery of Middle Kingdom statuary and royal inscribed blocks in the Delta, which were probably originally set up in the Memphis-Fayum area, suggests a precedent for the removal of statues from this locality by the Hyksos (Ryholt 1997: 82, 133, 143-148). The finding at Tanis of one sphinx originally inscribed for Amenemhat II, two sphinxes of Amenemhat III, a statue of Smenkhera of Dynasty XII, and two colossi of Imyremeshaw of Dynasty XIII, but with the name of the Hyksos king Aqenenra Apepi (Apophis) on them, further testifies to the Hyksos penchant for acquiring objects initially erected in Middle Egypt (Bourriau 2000: 196; Ryholt 1997: 133).

IV; Dunand 1928: 301-2), Tell Hezzin (statue of Sobekhotep IV; Montet 1954: 76; Helck 1983: 37), Qatna (sphinx of Ita; du Buisson 1928: Part 2, 10-11, Plate XII), Hazor (sphinx of Amenemhat III; Ben-Tor 2006a: 6), and Gezer (statuette of Sobeknefru; Weinstein 1974). Statues of Middle Kingdom officials were found at Ugarit, Qatna, Byblos, and Kamid el-Loz (Dunand 1927: 97, Plate XXV; du Buisson 1935: 45-46, Plate VI; Schaeffer 1939: 20-22, Plates III-V; Hachmann 1983: 159; Yon 2006: 16). Other statues of Egyptian nobles were discovered at Megiddo, Gezer, and Tell el-'Ajjul (Macalister 1912: 311-313, Fig. 450; Petrie 1931: Plates XXI-XXII, 1933: Plates XVI-XVII, 1934: XL; Loud 1948: Plates 265-266, 267). These statues of kings and nobles were excavated in contexts that suggest they were deposited long after their manufacture in Egypt (Weinstein 1974: 56; Helck 1976). As Egyptian texts emphasise the importance of Egyptians being buried in Egypt, the funerary statues appear out of context. Thus, these statues may have been sent to the Levant as interesting Egyptian objects that would be displayed by the Levantine rulers (Ahrens 2006: 26-27)[63].

Fragments of Egyptian or Egyptian-style pottery in levels dated to the late Second Intermediate Period were found at Tell el-'Ajjul (Fischer & Sadeq 2002: 131, 133-134). Stone vessels imported from Egypt appear at more sites than in the previous phases, including many inland localities, but there is a noticeable increase in their presence in southern Palestine (Sparks 1998: 510). The specific shape of these vessels implies they are trade items, as they differ from the common types in Egypt at the time (Sparks 1998: 510). Overall, at the end of the Second Intermediate Period, it appears that either due to events in the Levant and/or in Egypt, contacts may have become reduced.

## *2.4. The New Kingdom in Egypt and the Late Bronze Age in the Levant*

### 2.4.1. The New Kingdom in Egypt

The Kamose stela II states this king no longer wished to be a vassal of the Hyksos king Aauserra Apepi (Apophis). Kamose subsequently executed an attack on Avaris, possibly in his third regnal year (Bourriau 2000: 195, 211-212). However, the removal of the Hyksos occurred many years later under his successor, Ahmose. The event probably occured between Ahmose's 18th and 22nd regnal years (Table 2.8). The autobiographical tomb inscription of Ahmose son of Ibana (Ebana) at El Kab (Redford 1997: 15) indicates that after

[63] See also the discussion of the movement of statues in the 18th Dynasty in Forstner-Müller *et al*. 2002.

sacking Avaris, Ahmose followed the Hyksos king Khamudi to the city of Sharuhen, which was besieged for several years (Bourriau 2000: 210). This site has been identified as probably Tell el-‘Ajjul in southern Palestine (Kempinski 1974; Fischer & Sadeq 2000: 211)[64]. Other references to military action by Ahmose in the Levant are vague (Redford 1979: 274; Weinstein 1981: 5-6). Archaeologically, there is little evidence for destruction at Tell el-Dab$^{c}$a and the settlement appears to have continued (Bietak 1996: 67, 2007a: 432; Bietak in press). Most likely, Khamudi and his compatriots retreated to the Levant when it became clear they would not defeat Ahmose.

Table 2.8: Kings of the 18th Dynasty (after Shaw 2000: 481)

| **Nomen** | **Prenomen** |
|---|---|
| Ahmose | Nebpehtyra |
| Amenhotep I | Djeserkara |
| Thutmose I | Aakheperkara |
| Thutmose II | Aakheperenra |
| Thutmose III | Menkheperra |
| Hatshepsut | Maatkara |
| Amenhotep II | Aakheperura |
| Thutmose IV | Menkheperura |
| Amenhotep III | Nebmaatra |
| Amenhotep IV/Akhenaten | Neferkheperurawaenra |
| Neferneferuaten | Smenkhkara |
| Tutankhamun | Nebkheperura |
| Ay | Kheperkheperura |
| Horemheb | Djeserkheperura |

The reunification of Egypt had a marked effect on material culture throughout the country. Upper Egyptian pottery makes a sudden appearance at sites in Lower Egypt, particularly Memphis, where a new settlement was built after a period of inactivity, probably due to the war between Ahmose and the Hyksos (Bourriau in press). Memphis became the capital of Egypt once again and the Egyptian kings now wished to control territory in the Levant. The motivation behind the development of an “empire” in this area has been debated. Economically, the contribution of goods from southern Palestine to Egypt seems minimal; there were only a few commodities Egypt would have desired from the area (Ahituv

[64] Hoffmeier (1989: 184, 1991: 117-120) believes Sharuhen is more likely the site of Tell el-Far‘ah (S). Weinstein (1991: 106) offers a counter-argument in favour of Tell el-‘Ajjul.

1978)[65]. However, the occupation of Palestine did create a buffer zone between Egypt and the empires to the north and northeast, as well as providing a location to station troops that could be quickly deployed (Na'aman 1981: 184). In this light, the establishment of garrisons by Thutmosis III at the sites of Sumur (Tell Kazel), Ullasa (Tripoli?), Kumidi (Kamid el-Loz), Beth Shean, Joppa (Jaffa), and Gaza are significant (Na'aman 1981: 177). Further, these garrisons would have ensured the protection of inland trade routes, which provided access from coastal ports (Ahituv 1978: 105). Thus, the "empire" may have developed for commercial reasons, for security, and to enable Egypt to become more politically involved with the emerging empires of Mitanni, Babylon, and Hatti.

A gate inscription from Karnak appears to describe a campaign of Amenhotep I to the northern Levant (Redford 1979), although the attribution to this king is not certain (Table 2.8; Weinstein 1981: 6, 1991: 110; Hoffmeier 1989: 185). Biographies in the tombs of Ahmose Pennekhbet and Ahmose son of Ibana describe military action by Thutmosis I, which focused on the coastal area of Syria and seemed aimed at acquiring exotic goods (Pritchard 1955: 234; Bryan 2000: 234)[66]. Thutmosis II appears to have led a raid against the Shasu, probably in northern Palestine, while during Hatshepsut's reign there was possibly some military action at Gaza and in the general area (Weinstein 1981: 6).

Beginning with Thutmosis III there was a more permanent Egyptian presence in the region. Starting in Gaza and the city-states nearby, Thutmosis III eventually acquired territory in northern coastal Syria at the expense of the Mitanni Empire (Bryan 2000: 245-246; Redford 2003). Thutmosis III also laid siege to Megiddo where a large coalition of princes rebelling against Egypt were located. The aims of these missions appear to have been securing trade routes and acquiring booty. The latter was enough incentive to ensure Thutmosis III staged several more campaigns in the Levant, including one that led him all the way to the Euphrates (where Thutmosis I had also been) and that secured the territory south of Ugarit[67]. The result of these activities culminated in an alliance with Mitanni (Bryan 2000: 248).

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[65] Na'aman (1981) identifies problems in using the textual sources to determine the economic value of Palestine to Egypt. The Annals of Thutmosis III consist of booty and tribute, while the Amarna Letters do not specifically address the annual tribute sent by vassals to Egypt.

[66] Most of the information on Egyptian military campaigns in the Levant derives from inscriptions on stelae, tombs, and the walls of the major temples, particularly Karnak.

[67] Cities described as attacked in the northern Levant in the Annals of Thutmosis III include Tunip (Tell Asharneh), twice, Sumur (Tell Kazel), Irqata (Tell 'Arqa), Ardata (Tell Arde), Ullaza (Tripoli?), and Qadesh (Tell Nebi Mend), twice (Pritchard 1955: 238-241; Redford 2003: 15-16, 63-66, 70-71, 96-97). Redford (2003: 77) rejects the restoration of Qatna for col. 19.

Amenhotep II, Thutmosis III's successor, appears to have maintained peace with Mitanni, but also engaged in several campaigns in an attempt to control territory in northern Syria (Pritchard 1955: 245-248; Bryan 2000: 252). A stela from Memphis describes chiefs from Nahrin (Syria), Hatti, and Sangar (Babylon) bringing gifts to the Egyptian king and expecting to receive gifts in return. This exemplifies the age-old practice in the Levant of gift-giving between rulers as a form of diplomacy, which ultimate lead to acquiring commodities (Liverani 1990). These machinations solidified political relationships and were obviously effective, as Amenhotep II's successor, Thutmosis IV, married the daughter of the Mitanni king Artatama (Bryan 2000: 257). Inscriptions from Thutmosis IV's reign imply only limited military activity in the Levant, possibly against Mitanni and probably to quell rebellious city-states such as Gezer (Pritchard 1955: 248; Bryan 2000: 257-258).

The interactions between Egypt and the Levant, particularly the inland empires, acquired a more diplomatic character during the reigns of Amenhotep III and Amenhotep IV (Akhenaten). The discovery of clay tablet documents written in Akkadian at the site of Amarna (called the Amarna Letters) provides ample evidence for political relationships between Egypt and the eastern Mediterranean empires, as well as its vassal city-states in the Levant (Moran 1992). During the reign of Amenhotep III, correspondence was carried out between Egypt and Babylon, Mitanni, and Arzawa in south-western Anatolia. The Amarna Letters show that during the reign of Akhenaten, political relationships were established with the empires of Arzawa, Hatti, Mitanni, Assyria, Babylon, and Alashyia (undoubtedly southern Cyprus, see Goren *et al*. 2004: 57-62). The various city-states under Egypt's control incessantly fought against each other. For example, the Amurru kingdom was established through the defeat of several other city-states such as Ardata and Irqata in the Akkar Plain. Although still proclaiming itself a loyal vassal to Egypt, Amurru was essentially an empire within an empire. Despite these military disturbances, trade appears to have continued throughout Akhenaten's reign. During year 12, tribute from many of the Egyptian city-states was brought to the king (van Dijk 2000: 278)[68].

From the reign of Tutankhamen until the rule of Seti I, only a few military campaigns are attested in the Levant (Table 2.8). Tutankhamen's general, Horemheb, may have led several small campaigns against the Hittites during the early reign of this king (Pritchard 1955: 251; Martin 1989: 76-77, 89-91). Tutankhamen's immediate successor was Ay, who

[68] Important city-state vassals in Akhenaten's reign include Tunip (Tell Asharneh), Qatna, <u>Sumur</u> (Tell Kazel), Irqata (Tell 'Arqa), Qadesh (Tell Nebi Mend), Ardata (Tell Arde), <u>Ullaza</u> (Tripoli?), Byblos, Beirut, <u>Kumidi</u> (Kamid el-Loz), Sidon, Tyre, Hazor, Akko, Megiddo, <u>Beth-Shean</u>, <u>Joppa</u> (Jaffa), Gezer, Jerusalem, Ashdod, Ashkelon, Lachish, and <u>Gaza</u> (Moran 1992). (Those underlined were Egyptian administrative centers)

appears to have attempted to make peace with the Hittites, although a truce was not achieved (van Dijk 2000: 291-293). During the reign of Horemheb, additional military action failed to regain the Egyptian territory of Amurru and Qadesh (Klengel 1992: 115)[69].

The 19th Dynasty saw several notable confrontations between Egypt and the Hittites (Table 2.9). Seti I, who engaged in some small-scale wars in northern and southern Palestine, also fought a battle at Qadesh and against the Amurru state (Pritchard 1955: 253-254; Murnane 1985). The outcome was the reacquisition of these areas, increasing Egypt's territory northward (Klengel 1992: 117). However, this was short-lived as a second war directly with the Hittites resulted in the loss of both Qadesh and Amurru and a temporary truce with Hatti (van Dijk 2000: 295-296). With the accession of Ramesses II, military action in the Levant and against the Hittites resumed (Pritchard 1955: 255-258)[70]. The first campaign reacquired the fickle loyalty of the Amurru state, only to be subsequently lost to the Hittite king Muwattalli II (Klengel 1992: 168-169). Eventually, the situation came to a head at the battle of Qadesh in which Egypt was forced to retreat (Edel 1997; Kitchen 1999: 136-144). Ultimately, due to the threat of Assyria towards Hatti, the Hittite King Hattusili III and Ramesses II agreed to a peace treaty, in ca. 1258 BC. whereby the territory of Amurru and Qadesh remained with the Hittites (Beckman 1999: 90-95; Klengel 1992: 119). Little action by the remaining kings of the 19th Dynasty is recorded, with the exception of Merenptah who led campaigns against the vassals of Yenoam, Gezer, and Ashkelon (van Dijk 2000: 302).

Table 2.9: Kings of the 19th Dynasty (after Shaw 2000: 481)

| **Nomen** | **Prenomen** |
|---|---|
| Ramesses I | Menpehtyra |
| Seti I | Menmaatra |
| Ramesses II | Usermaatra Setepenra |
| Merenptah | Baenra |
| Amenmessu | Menmira |
| Seti II | Userkheperura Setpenra |
| Saptah | Akehnrasetepenra |
| Tausret | Sitameritamun |

[69] Both areas were important for trade as Amurru encompassed the western end and Qadesh the eastern end of the Akkar Plain, the only gap in the Lebanese mountains providing access from the Mediterranean to the Orontes and inland Syria.

[70] Cities mentioned in the campaigns of Seti I include Ullaza, Qadesh, Tyre, Beth ʻAnath, Hazor, Akko, Yenoʻam, Beth Shan, Pella, Hammath, and Gaza (Hasel 1998: 119-151, Fig. 12). Cities listed for Ramesses II include Tunip, Qadesh, Beth ʻAnath, Akko, Yenoʻam, Beth Shan, Pella, Dor, Aphek and Sharuhen (Hasel 1998: 152-178, Fig. 13).

The kings of the 20th Dynasty focussed on maintaining their territory in the southern Levant as the region became increasingly unstable (Table 2.10). The peace with Hatti continued and Egypt even sent supplies of grain to the Hittites who were under threat from the "Sea Peoples" (van Dijk 2000: 303). Eventually, the Hittite capital of Hattusas fell, possibly to these invaders (Kuhrt 1995: 265-266). Egypt appears to have lost control of most of the coastal plain early in the reign of Ramesses III (Bietak 1993). However, domination over vassals in southern Palestine and in the Jezreel Valley continued until after the reign of Ramesses VI, when the Egyptian empire in the Levant came to an end (Weinstein 1981: 22-23; Finkelstein 2000: 161-162; Bietak 2007a: 443)[71].

Table 2.10: Kings of the 20h Dynasty (after Shaw 2000: 481)

| Nomen | Prenomen |
|---|---|
| Sethnakht | Userkhaura Meryamun |
| Ramesses III | Usermaatra Meryamun |
| Ramesses IV | Heqamaatra Setepenamun |
| Ramesses V | Usermaatra Sekheperenra |
| Ramesses VI | Nebmaatra Meryamun |
| Ramesses VII | Usermaatra Setepenra Meryamun |
| Ramesses VIII | Usermaatra Akhenamun |
| Ramesses IX | Neferkara Setepenra |
| Ramesses X | Khepermaatra Setepenra |
| Ramesses XI | Menmaatra Setepenptah |

### 2.4.2. The Late Bronze Age in the Levant

The end of the MBA in the Levant was marked by the destruction and abandonment of many cities (e.g. Megiddo, Shechem, Ta$^c$anach, Gezer, Tell el-'Ajjul), while the re-establishment of towns featuring a different material culture denoted the beginning of the LBA (Weinstein 1981, 1991, Dever 1990)[72]. The groups/kings responsible for these destructions have been much debated. Furthermore, they occurred at different times at various sites and probably lasted a century (Weinstein 1982)[73]. Most have been dated from the reigns of Ahmose to Thutmosis III, implying that campaigns during the early 18th Dynasty were responsible (Weinstein 1981: 4-5; Dever 1992: 13). Sites in southern Palestine

[71] Weinstein (1992b) sees the loss of Egyptian domination of southern Palestine as occurring after the reign of Ramesses IV.
[72] The lack of archaeological remains from the LB I makes it difficult to reconstruct events for this period.
[73] Dever (1990: 76) acknowledges that most of the destruction is around the gate areas while other parts of the site lack such evidence. Hoffmeier (1991:117) notes that the predilection of archaeologists to focus on destroyed fortifications may have led to an inflated sense of destruction in Palestine.

with evidence of early destruction are attributed to the Egyptian retaliation against any city perceived as having connections to the Hyksos (Weinstein 1981: 5-7). The sites along the northern coast were presumably attacked by Amenhotep I and Thutmosis I on their way to Syria, while Thutmosis III attacked Megiddo (Weinstein 1981: 10-12).

However, the archaeological and textual evidence are not in concordance. Hoffmeier (1989, 1990, 1991, 2004) proposes that the destruction was due to internal strife[74], that there was no benefit to Egypt in destroying many sites in Palestine, and that the Egyptian army had neither the strength nor the time to attack numerous well-fortified cities. Na'aman (1994) suggests that the incursion of Hurrians from the north may have lead to the destruction of these cities[75]. Further, most of the military action of the early 18th Dynasty pharaohs was focused in northern Lebanon and Syria, rather than Palestine. Since troops could be moved to the region by ship, control of Palestine (except for a few ports) for these engagements was not necessary (Na'aman 1994: 181-182). Finally, the *Annals of Thutmosis III* listing cities in the Levant may not be those attacked or destroyed, but rather a listing of sites known to traders and emissaries. Collectively the city names were used to represent the entire area of the Levant under threat from Thutmosis (Redford 2003: 45).

In the northern Levant, the destruction at the end of the MBA of first Alalakh and then Aleppo by the Hittites seems to have caused widespread decline in the area (Van De Mieroop 2007: 105, 121-122). Many sites show abandonment and/or destruction, followed by resettlement on entirely different plans, i.e. Qadesh (Bourke 1993: 162). The Hurrians had grown in numbers, and by the early 15th century BC they had established the empire of Mittani (Fig. 2.9; Klengel 1992: 85-90; Kuhrt 1995: 286). By the mid-15th century BC, city-states such as Alalakh, Aleppo and Qadesh were under Mitannian control, while for a brief period Qadesh was under Egyptian control (Klengel 1992: 94-95; Van De Mieroop 2007: 142-143, 150, 165)[76]. The power of the Mitanni Empire began to fade around the mid-14th century BC (Kuhrt 1995: 289-296). During the reign of the Hittite king Suppiluliuma I (1344-1322 BC), the empire was conquered and made into a Hittite vassal along with the former Mitannian vassals of Aleppo, Ugarit, Amurru, and Qadesh (Klengel 1992: 109-115; Kuhrt 1995: 252-253, 307). At the same time, the eastern edge of Mitanni was under constant threat from Assyria (Van De Mieroop 2007: 153, 159, 165). By ca. 1340 BC Ugarit

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[74] Bienkowski (1989: 176) suggests that the late MBA fortification of sites in Palestine was to due internal conflict, which may also have led to the emigration of people to Egypt.

[75] This event would have occurred in the second half of the 16th century based on the Low Chronology (Zeeb 2004).

[76] Most of the historical information for this period derives from the archives of cuneiform clay tablets found at Hattusa, Alalakh, Ugarit, and Amarna (Van De Mieroop 2007: 164).

was a vassal of Hatti, but maintained its own ruling dynasty (Klengel 1992: 130-139). The site provided a connection point between the empires of Hatti and Egypt, and was a crossroad for trade between the east and the Mediterranean. The frequent battles of the 13th century BC between Hatti and Egypt did not alter the border permanently, although the coastal city-states changed allegiance based on who was gaining territory (Klengel 1992: 106-120).

The increasing power of Assyria resulted in its acquisition of the former Mitanni territory (Fig. 2.9; Van De Mieroop 2007: 160). This culminated in a direct attack by Assyria on the Hittites during the reign of the Assyrian king Tukulti-Ninurta I (1243-1207 BC; Klengel 1992: 127). The Hittite vassals in western Syria also began to rebel, but this did not last long. The coastal kingdom of Amurru signed a treaty with the Hittite king Tudhaliya IV (1237-1209 BC) in which it agreed not to trade with Assyria (Beckman 1996: 98-102). This highlights the role of the Amurru region for moving goods from the Mediterranean to the inland empires. By the accession of the Hittite king Suppiluliuma II (1207-? BC) the empire had lost most of its control over Syria (Kuhrt 1995: 265). Eventually, the Hittite capital of Hattusa was sacked and Ugarit was destroyed. Other cities attacked around this time included Alalakh, Tell Abu Hawam, Hazor, Ashdod, and Ashkelon The harbour towns of Byblos, Sidon, Sarepta, and Tyre were left intact, as were the inland sites of Kamid el-Loz (Kumidi) and Tell Dan (Laish) (Van De Mieroop 2007: 195, 220). By around ca. 1200 BC, most of the empires in the Near East had fallen and new groups of people were on the move.

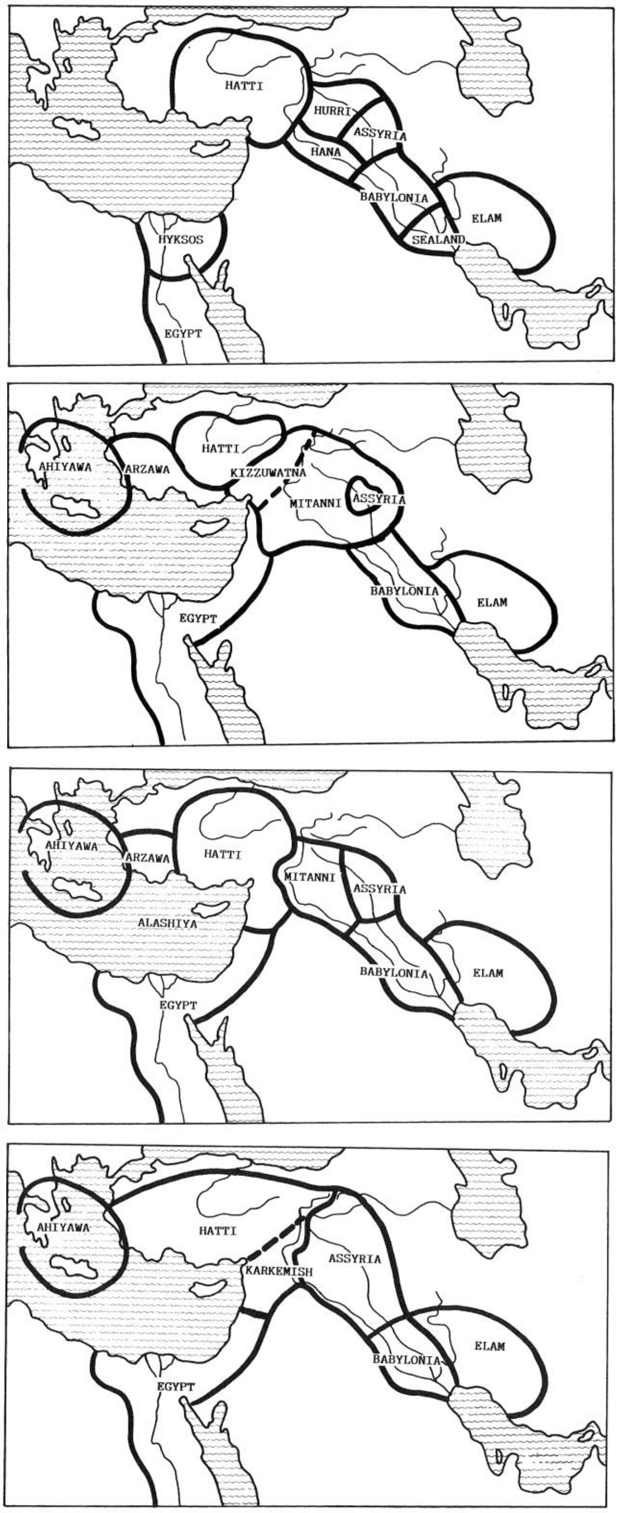
Fig. 2.9: LBA Empires in the Levant (Liverani 1990: Figs. 1-4)

ca. 1600 BC

ca. 1450 BC

ca. 1350 BC

ca. 1220 BC



### 2.4.3. Contacts between Egypt and the Levant in the LBA

The brief historical outline above reveals the extensive contact between Egypt and the Levant in the LBA. Commodities moved between Egypt and the Levant in the form of greeting gifts between kings and vassals (seen in the Amarna Letters, Moran 1992), tribute from vassals (also in the Amarna Letters), booty from military campaigns (Egyptian inscriptions) and trade, either conducted privately or overseen by the state or its rulers (Ugarit tablets; Heltzer 1978: 121-143; Sauvage 2005)[77]. Most evidence seems to suggest the secure acquisition of Levantine goods was a primary motivator in Egypt's maintaining territory in this region.

For the purpose of the discussion of changes between MBA and LBA trade, the presence of Egyptians in the Levant in the LBA is significant, and may have affected trade between the two regions[78]. Evidence for the Egyptian presence in the Levant derives mostly from the discovery of Egyptian architecture, pottery and a few other objects at key sites[79]. The earliest Egyptian object, dated to the reign of Ahmose, is a stone vase, found at Qatna, inscribed as a gift to the Chief Treasurer Neferperet from Ahmose-Nefertari (Ahrens 2006: 27-26)[80]. With the campaigns of Thutmosis III[81] and the development of an Egyptian administrative system to oversee the Levantine territory, evidence for an Egyptian presence becomes stronger. For example, Beth Shean was an Egyptian garrison from the 18$^{th}$ Dynasty until the middle of the 12$^{th}$ century BC (Mullins 2006: 247). Egyptian-style[82] vessels first appeared here in the second half of the 15$^{th}$ century BC but made up a small percentage of the pottery (Mullins 2006: 251, 253-254, 259). During the 19$^{th}$ and 20$^{th}$ Dynasties, Egyptian-style vessels, particularly simple bowls, were more numerous, while Egyptian imports consisted of a handled cup and an amphorae (Mullins 2006: 252-254, 259; Martin 2007)[83]. This pattern of locally produced Egyptian-style household pottery and imported amphorae and handled cups is seen at other sites such as Tel Aphek, Tel Mor, and Tel Sera$^{c}$ (Martin 2007: 376).

[77] Although concerning primarily LBA trade with the Aegean, Cline (1994: 85-88, 106-107) provides a general summary of the mixed mechanisms that were in operation to move objects around the Eastern Mediterranean.
[78] Higginbotham (2000) interprets the Egyptian material in the Levant as evidence for emulation by the Canaanite elites, rather than direct Egyptian presence; this view has not been widely accepted.
[79] Weinstein (1981: 18-22) provides a review of the remains in Palestine for an Egyptian presence during the early to mid 19$^{th}$ Dynasty.
[80] The object is suggested to have arrived later than Ahmose's reign.
[81] A scarab inscribed for Thutmosis III was found in a LBA tomb in Beirut (Ward 1993-1994: 213).
[82] Egyptian-style refers to pottery nearly identical in form to contemporary Egyptian ceramics but determined to have been produced at sites in the Levant based on macroscopic analysis of the fabrics.
[83] A petrographic study of some of the Iron Age I Egyptian-style pottery from Beth Shean suggests the majority were locally made with only a few imported examples (Cohen-Weinberger 1998).

Deir el-Balah was apparently an Egyptian administrative settlement during the 18th Dynasty and a fort with a settlement and cemetery during the 19th Dynasty (Dothan 1987). Petrographic investigation of Egyptian ceramics, comprising roughly 80% of the ceramic corpus, at the site revealed that the majority were locally produced (Goldberg *et al*. 1986). Tell el-‘Ajjul produced some sherds and complete vessels of Egyptian and/or Egyptian-style pottery in levels dated to the LBA/18th Dynasty (Fischer & Sadeq 2002). Other sites with evidence for Egyptian architecture and pottery (either imported or locally produced) are Tel Sera‘, Tell el-Far’a (S), Lachish, Megiddo, Tell Jemmeh, Tel Hesi, Tel Masos, and Aphek (Fig. 2.10; Oren 1984). One imported vessel and several local copies of Egyptian-type ceramics were found at Megiddo (Martin 2009). Tel Sera‘ featured a high point of Egyptian activity during the 13th and 12th centuries BC, with Egyptian architecture (“Governor’s Residency”), hieratic inscriptions, scarabs, and imported alabaster, glass, and faience vessels, along with locally manufactured Egyptian pottery (Oren 1993a: 1331; Martin 2008: 246, 2004: 265). Ashkelon also had an “Egyptian Fortress” with Egyptian-style pottery and some imported Egyptian vessels, particularly amphorae, from the late 19th to the early 20th Dynasties (Martin 2008). During the same period, locally produced Egyptian-style pottery and a few imported examples were reaching Tel Dan (Martin 2007). Other sites with assemblages of Egyptian-style pottery and imports dating to the 13th to 12th century BC are Tell Abu Hawam, Tel Aphek, Jaffa, Tel Mor, Tell es-Sa$^{c}$idiyeh, Ashkelon, Tell el-$^{c}$Ajjul, Yoqne$^{c}$am, Meggido, and Tell el-Far$^{c}$ah (S) (Martin 2008: 246, 2007: 195, 198, 200, 2004: 265). Imported Egyptian amphorae were mostly found at coastal sites, particularly those with evidence for Egyptian architecture (Martin 2008: 265). This includes the sites of Akko, Tell Abu Hawam, Tel Nami, and Tel Mor (Martin 2008: 265-266). By the late 12th century BC, Egyptian-style pottery was rarely found in the northern Levant, although examples from a number of sites in southern Palestine are known (Weinstein 1998: 191).

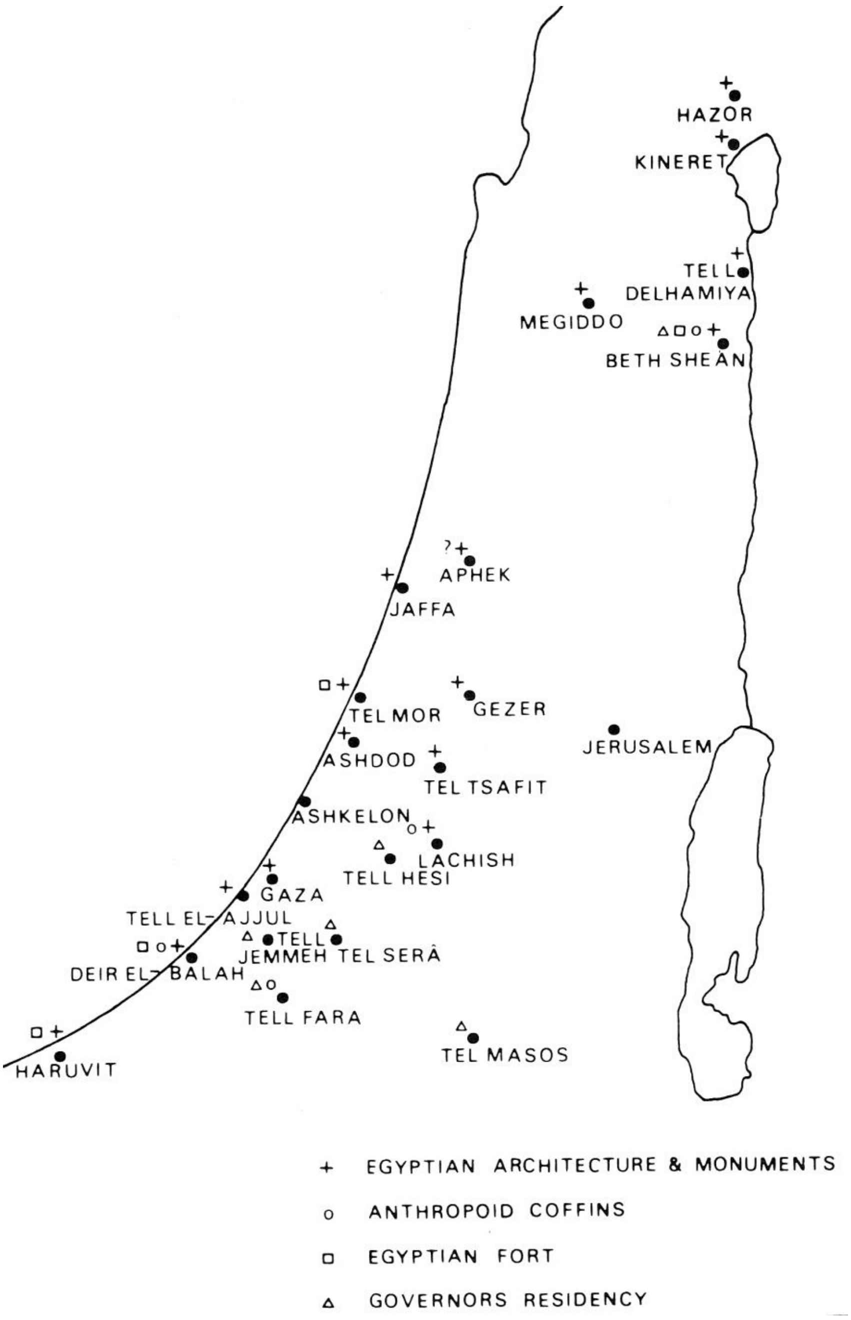
This overview of the archaeological evidence for an Egyptian presence in southern Palestine highlights the Egyptian’s emphasis on the coastal region[84]. Control of more inland regions such as the Jordan Valley appears to have been indirect[85]; the administrative centres of Tell Abu Hawam and Beth Shan may have played a role. The first site, located at the western end of the Jezreel Valley in Haifa Bay, provided access to the Mediterranean, while the latter site was idelly located at the junction between the Jezreel Valley and the Jordan

[84] The towns in Palestine sending letters to Amarna in the 18th Dynasty also suggests more involvement with coastal sites than those to the east of the Jordan Valley (Moran 1992).

[85] E.g. Egyptian artefacts were found at Pella on the eastern side of the Jordan Valley (McNicoll *et al*. 1992: 59-64).

Valley. Additionally, most Egyptian activity appears to have been focussed in southern rather than northern Palestine. One explanation is that the Egyptians may have had a stronger need to fortify their border with southern Palestine, along with providing locations for restocking troops moving by land between the Levant and Egypt. Additionally, the locations of the administrative centres along the coast and in areas where both goods and people would have been moving may indicate that Egypt's empire in this region was also established for the purpose of engaging in lucrative trade with the Levant.

Fig. 2.10: Sites with evidence for an Egyptian presence in southern Palestine (Oren 1984: Fig. 1)



## 2.5. *Conclusions*

The above historical overview is intended to illustrate the existing evidence for contacts between Egypt and the Levant during the MBA and LBA. This information provides a context for the discussion of the movement of Canaanite jars to Egypt in these periods. Obviously, the presence of foreign objects in both areas suggests contact; however, these items provide little information on the movement of commodities. During the Middle Kingdom, some evidence illustrates trade, while the enormous quantity of imported pottery at Tell el-Dab$^{c}$a confirms many goods arrived in the Delta. Nevertheless, information on the movement of commodities within Egypt is lacking. Similarly, during the LBA the presence of Egyptians in the Levant and the multiple military campaigns do little to clarify the nature of trade for this period, although the presence of imported pottery in Egypt indicates goods arrived from many areas in the Eastern Mediterranean. Further, changes in trade between the two periods due to the many political developments are poorly defined. The examination of Canaanite jars is a means for further refining our understanding of trade during the MBA and LBA.

# Chapter 3: Kom Rabi'a Excavation and Canaanite Jars

## 3.1. *Introduction*

During the Middle Kingdom and Second Intermediate Period, few Canaanite jars were found in Egypt outside the Eastern Nile Delta. Those recovered from the excavations at Kom Rabi'a, a part of the ancient city of Memphis, reveal that the jars were acquired by areas outside the Delta. The stratigraphic excavation of this site and the thorough analysis of the jar sherds provides a unqiue opportunity to examine their context, vessel form, and variation in fabrics, information that can be related to their petrographic study. Examination of the prevalence of Canaanite jars in the excavated strata shows their relative rarity in comparison to Egyptian pottery, although certain periods witnessed more examples than others. This increased knowledge of these vessels is important as only a few studies have examined Canaanite jars. General studies of their form reveals a gradual evolution during the MBA and LBA, with variety in rim types noticeable. Their utilization for carrying diverse commodities is illustrated by their form, artistic representations, commodity labels, and the analyses of residues found inside the jars. Examination of their distribution in the Levant and Egypt shows their increased presence in the latter region during the LBA. Canaanite jars were important transport containers that were traded throughout the Eastern Mediterranean.

## 3.2. *Excavation and Pottery at Kom Rabi'a*

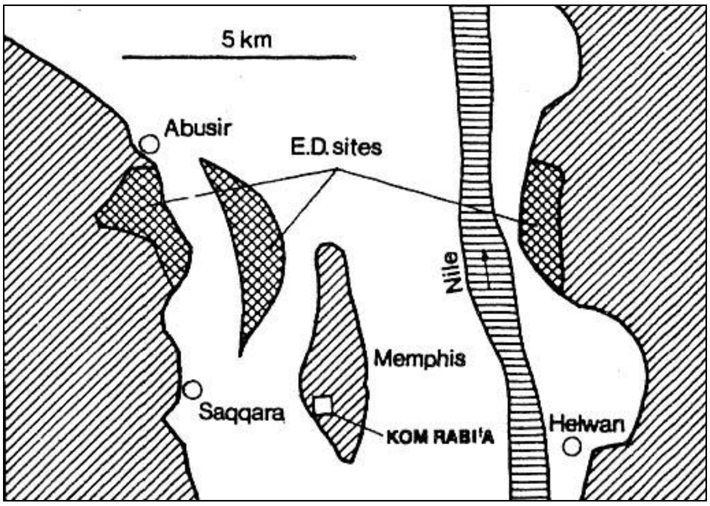
### 3.2.1. Excavation

The site of ancient Memphis is located 300 meters south of the town of Mit Rahina on the western bank of the Nile between the river and the plateau of Saqqara (Fig. 3.1). The ruin field covers an area of 6 square kilometres and features the remains of the Great Temple of Ptah, a settlement mound, and an additional 150 sites in the area. During the early 20th century, archaeological investigations of the area were conducted by Petrie (1909a, 1909b, 1911; Petrie *et al.* 1910; Petrie *et al.* 1913; Engelbach 1915) on six occasions[86]. Petrie documented the New Kingdom monuments and existing walls, cleared the Temple of Ptah, and excavated a palace believed to belong to the 26th Dynasty king Apries. The next excavator at the site was Badawi (1948), who focused on the New Kingdom stone inscriptions, either still at the site or previously recorded. In the 1950s, two seasons of

[86] See Jeffreys (1985: 12-14) for a discussion of earlier exploration of the site.

excavation were carried out by the University Museum of the University of Pennsylvania (Anthes 1959, 1965). These archaeological excavations examined the small temple of Ramesses II, the enclosure wall of the Temple of Ptah, and the wall of Merenptah. The results of these investigations also provided a first understanding of the complicated New Kingdom statigraphy of the area (Jeffreys 1985: 16). Survey of the area was carried out by Jeffreys (1985) between 1981 and 1983.

Fig. 3.1: Map of Memphis (Jeffreys & Giddy 1993: 7)




Excavations by the Egypt Exploration Society concentrated on the mound south of the Temple of Ptah called Kom Rabi'a (Jeffreys 1985). This work began in 1984 and continued until 1990 under the direction of H.S. Smith, D. Jeffreys and L. Giddy[87]. The site was chosen due to the presence of standing post-New Kingdom mud-brick walls and the identification of sherds dating to the Middle Kingdom in a pit. Additionally, archaeological exploration was necessary to determine why the heights of the tells in the area were above the remains of the temple, as well as the reason for the site's slope from west to east (Jeffreys 2006: 1). Excavation in this area uncovered a stratified archaeological sequence dating from the 13$^{th}$ to 26$^{th}$ Dynasties, ca. 1750 - 525 BC (Jeffreys 1985: 26). A 500 square meter area was excavated in the south-western section of the ruin field, in the north-western quadrant of Kom Rabi'a[88] (Fig. 3.2; Jeffreys 2006: 11-30). Level 0 was the levelled and disturbed surface debris on the site and contained finds of New Kingdom, Third Intermediate Period, and later

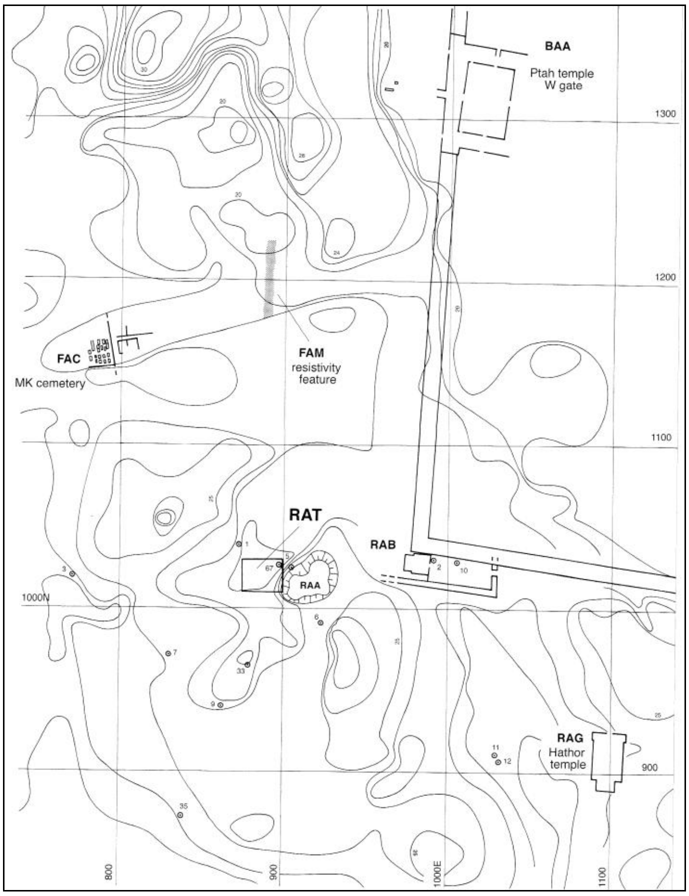
[87] Preliminary excavation reports appear in the Journal of Egyptian Archaeology: Jefferys, Malek, & Smith (1986), Jefferys, Malek, & Smith (1987), Jeffreys & Malek (1988), Jeffreys & Giddy (1989), Giddy, Jeffreys, & Malek (1990), Giddy & Jeffreys (1991), Giddy &Jeffreys (1993), Giddy, Jeffreys, & Bourriau (1996), and Jeffreys, Bourriau, & Johnson (2000)
[88] This site was given the code RAT (Kom **R**abi'a area **AT**) and all finds were labelled by this code (Jeffreys 1985: 2, Fig. 8).

date (Table 3.1; Aston & Jeffreys 2007: 6-8).  Poorly preserved occupational structures of Third Intermediate Period date, Level I, were found in the east and south-east of the excavated area (Aston & Jeffreys 2007: 6).

Table 3.1: Excavated Kom Rabi'a levels and their tentative dates (Jeffreys 2006: 1-3; Aston & Jeffreys 2007: 6-8, 17; Gallorini pers. comm.; Bourriau pers. comm.)

| Level | Relative Date |
|---|---|
| 0 | disturbed surface |
| I | 20th Dynasty – Third Intermediate Period |
| IIa | Mid-Late 19th Dynasty |
| IIb | Early-Mid 19th Dynasty |
| IIIa | Late 18th Dynasty – Early 19th Dynasty |
| IIIb | Mid-Late 18th Dynasty |
| IV | Early-Mid 18th Dynasty |
| V | Second Intermediate Period – Early 18th Dyn. |
| VI | Mid-Late 13th Dynasty |
| VIIa | Mid 13th Dynasty |
| VIIb | Mid 13th Dynasty |
| VIII | Late Twelfth Dynasty – early 13th Dynasty |

Fig. 3.2: Area of Excavations at Kom Rabi'a (Jeffreys 2006: Plan 1)

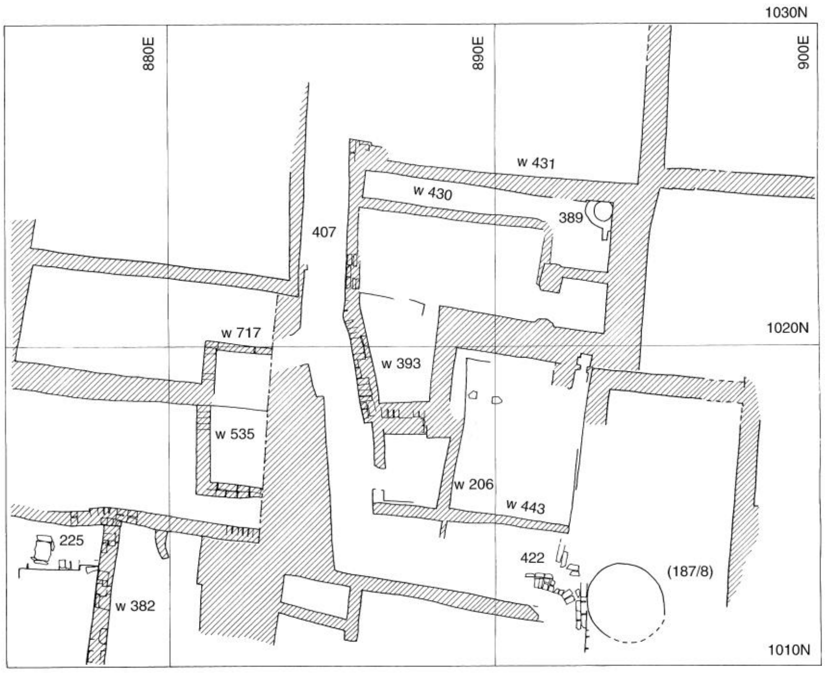


The deposits in Level II were dated to the 19th and 20th Dynasties (Fig. 3.3; Jeffreys 2006: 11-24). A large silo was exposed in the south-east corner with streets, along which were small houses and courtyards, radiating from this area. On the west side of a north-south boundary wall were found small houses, while to the east of the wall a series of narrow rooms (possibly magazines) and two slightly larger houses were excavated. Some houses were interpreted as priests' houses in the eastern section, while most houses exhibited evidence of craft production (Giddy 1999; Jeffreys 2006: 23, 67). Level III dated to the mid to late 18th Dynasty and featured houses with a similar layout to those in Level II (Fig. 3.4; Jeffreys 2006: 24-27). Because of the sloping nature of the site and the complicated stratigraphy, Levels IV and V were only exposed in small trenches in the north and west of the excavated area. Level IV was dated to the early to mid 18th Dynasty and featured the ephemeral remains of houses built on a plan that was followed by the buildings in the later levels (Jeffreys 2006: 27-30)[89]. Therefore, the houses built in Level IV determined the settlement layout throughout the New Kingdom. Below this level was found a layer of sand, Level V, which sealed the earlier layers below (Jeffreys 2006: 30-36).

Fig. 3.3: Plan of Level II (Jeffreys 2006: Plan 4)


[89] As the structures in this level were only preserved to the height of one brick, a complete plan was not possible (Jeffreys 2006: 28-29).

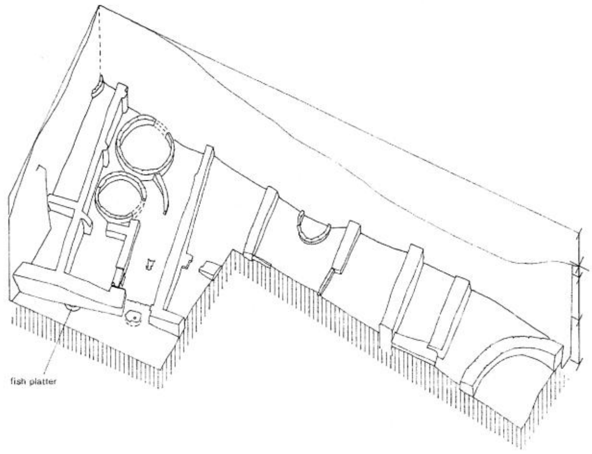
Fig. 3.4: Plan of Level III (Jeffreys 2006: Plan 5)




Archaeological remains dating before the New Kingdom were located predominantly on a series of terraces in the northern section of the excavation (Jeffreys & Giddy 1993: 5, 7). In this north-western area, two trenches were excavated, one 25 x 4 meters and one 10 x 6.5 meters (Giddy 1999: 1; Jeffreys 2006: 3)[90]. The top section of Level VI, just below Level V, consisted of a layer of silt deposits, possibly associated with flooding of the site by the Nile (Jeffreys 2006: 32). Mixed in with these silt deposits of Level VI was destruction debris of earlier buildings oriented differently from the New Kingdom levels and dating to the Second Intermediate Period (Fig. 3.5)[91]. Below this and still within Level VI, the remains of three rooms were found containing evidence for storing and preparing food Jeffreys & Giddy 1993: 7). These rooms were located to the west of a boundary wall, while to the east was a possible silo. The trajectory of this boundary wall was the same as that for the boundary wall in the New Kingdom, suggesting some continuity in settlement layout based on the presence of this large feature.

[90] Comparison of material between the New Kingdom and Middle Kingdom levels (see Chapter 7) must take into account the reduced area of exposure for the Middle Kingdom levels.
[91] The excavation results from the Middle Kingdom and Second Intermediate Period levels will be shortly published by L.Giddy , titled: Kom Rabi'a: The late Middle Kingdom Phases (Levels VI-VIII).

Fig. 3.5: Axonometric Plan of Level VI (Jeffreys & Giddy 1989: 4, fig. 2)




The structures of Level VI followed those in Level VII, the latter being divided into several phases designated Levels VIIa-d to reflect a series of rebuildings carried out on the same plan (Fig. 3.6 and Fig. 3.7; Gallorini & Bourriau in press). Within the Level VII rooms were found evidence of food preparation and the storage of liquids in vessels, along with tools associated with working turtle shell and metals (Jeffreys & Giddy 1989: 1-8; Jeffreys & Giddy 1993: 7-8). Unfortunately, the high water table prohibited further excavation beyond Level VIII, which contained a very limited and unrepresentative amount of material due to the water (Giddy & Jeffreys 1991: 1-4; Gallorini pers. comm.). Although only a small area of Kom Rabi'a has been examined, it provides a record of occupation from the 13th Dynasty through the end of the Third Intermediate Period. Its small houses and workshops indicate a lower to middle class group of priests and artisans.

Fig. 3.6: Axonometric Plan of Level VIIa (Jeffreys & Giddy 1989: 4, fig. 2)

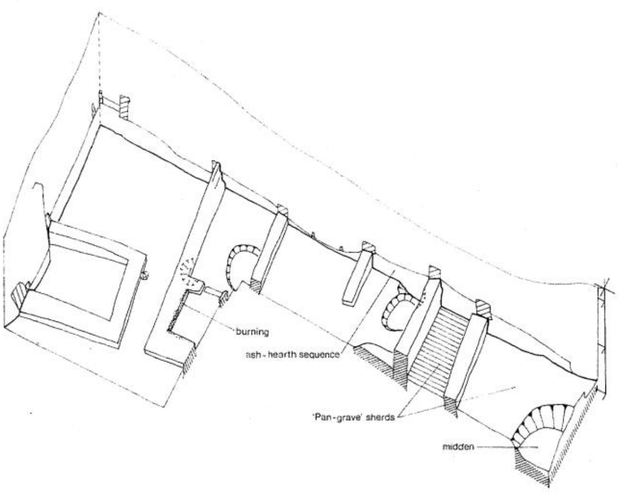
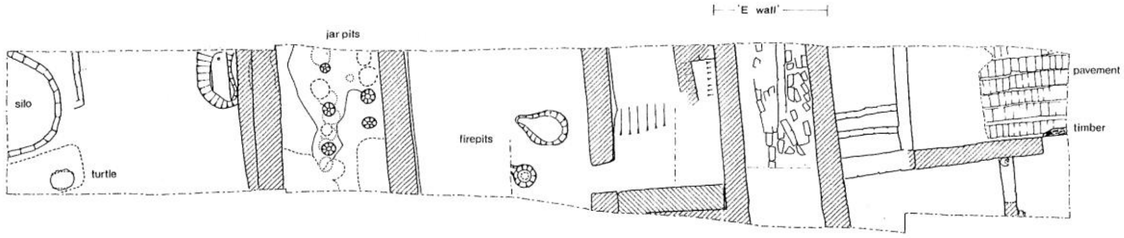


Fig. 3.7: Plan of Level VIIb (Giddy & Jeffreys 1991: 2, fig. 1)




### 3.2.2. Pottery

The excavations at Kom Rabi'a produced an enormous quantity of ceramic material. A strategy for analyzing this material was developed by J. Bourriau. For each context, all of the material was examined and sorted into wares, based on technology, either hand or wheel-made, fabric, surface treatment, and shape when it could be determined (Bourriau 1986: 23; Bourriau & Gallorini in press). Within each ware, the material was weighed before the non-diagnostic sherds were removed. This provided data to characterize every context before the sherds were discarded, and permitted comparison between contexts. Diagnostic material, i.e. rims, bases, handles, shoulders, decorated sherds, and imported fabrics, were saved for further analysis. This still resulted in an enormous quantity of material that needed to be sampled, as time and resources did not permit analysis of all the diagnostic sherds[92]. For the compressed New Kingdom levels, all of the contexts were sampled, while only 78% (465 of 602 contexts) of the Middle Kingdom contexts were selected for sampling due to the more gradual change in pottery types that had been observed (Bourriau & Gallorini in press) [93]. A random selection of rims was first taken from the sampled contexts, followed by a purposive sample of sherds including those of foreign fabric (Bourriau 1986: 23)[94].

Pottery in the post-New Kingdom Levels I and 0 was from a range of dates, with only a few pieces dating to the 20th Dynasty (Aston & Jeffreys 2007). The pottery from the New Kingdom levels showed considerable differences from the familiar repertoire of funerary material from sites such as Saqqara, Sedment, Gurob, Haraga, and Riqqa (Bourriau & Eriksson 1997) [95]. Nevertheless, points of similarity were sufficient to secure the dating.

[92] However, for the few Third Intermediate Period contexts all of the diagnostic material was recorded and analyzed (Aston & Jeffreys 2007).
[93] Figures derive from the database for recording the Middle Kingdom and Second Intermediate Period pottery (developed and maintained by Bourriau & Gallorini).
[94] See Bourriau 1991b, 1992, and Bourriau & Gallorini in press for additional information on the sampling procedures.
[95] Preliminary reports on the pottery appeared in Bulletin de Liaison due Groupe International d'Étude de la Céramique Égyptienne: Bourriau (1986, 1987, 1988, 1990a, 1991a, and 1992), Bourriau & Aston (1985a), and Bourriau & French (1984).

Most of the pottery can be classified as table ware, cooking vessels, and storage containers. Foreign pottery included Canaanite jars, Nubian Kerma cooking pots (Bourriau 1991c: 136, Fig. 3), Mycenaean pottery, and one sherd from a Minoan vessel (Bourriau & Eriksson 1997: 96-101, 107). Cypriot pottery appeared in levels from the Second Intermediate Period to the 19th Dynasty, and included Cypriot Base Ring I and II, and Red and Black Lustrous Wheel-made wares[96]. The Middle Kingdom pottery was also primarily domestic in character. The vessel forms have parallels in the excavations at Dahshur, Lisht, and Tell el-Dab$^{c}$a (Arnold 1982, 1988; Bader 2007, 2009). In the sand layer (Level V), a few examples of Tell el-Yahudiyeh juglets made of Nile clay were found. Within Levels VI and VII, imported pottery included Canaanite jars, a Cypriot Base Ring juglet, examples of Tell el-Yahudiyeh in a non-Egyptian fabric, and Nubian sherds belonging to the Pan-grave culture (Bourriau 1991c: 132).

In comparison to the New Kingdom corpus, the Middle Kingdom pottery exhibits different shapes, fabrics, and decoration, as well as different methods of manufacturing and finishing (Bourriau & Eriksson 1997: 102-104; Bourriau & Gallorini in press). The evolution in pottery types from the mid-13th Dynasty through the Second Intermediate Period was gradual, with the exception of the open forms. These vessels had hand-finished bases in the 12th Dynasty, while in the 13th Dynasty the bases were wheel-finished. Form changes in the hemispherical cups and beer bottles provided a method for relating the Memphis material to that at other settlements of similar date such as Tell el-Dab$^{c}$a and Lisht (Bader 2007, 2009; Arnold 1988). Thus, this links Kom Rabi'a Level VIII and possibly Stratum G/4 at Tell el-Dab$^{c}$a, Level VII with Stratum G/3-1, and Level VIe with Stratum F (see Fig. 2.8 and Chapter 2 for a discussion of the Tell el-Dab$^{c}$a strata). However, the two corpora diverged between Strata F and E/2 at Tell el-Dab$^{c}$a and Levels VIe and VIc at Kom Rabi'a, just before the 15th Dynasty at the former site. In fact, the different hemispherical cups at each site provide an additional synchronism between Stratum E/1 and Level VIc. This difference in ceramics appears to indicate a break in contact between the two sites as the Dynasty XV rulers came to power (Bader 2007: 265, 2008: 216-217, 2009: 680-707). Such a lack of contact may suggest little direct presence or control of Memphis by the Hyksos.

The randomly sampled pottery from the New Kingdom and Middle Kingdom levels allowed for the quantity of imported pottery to be estimated. While all Canaanite jar sherds were collected, only those within the random sample can be employed for assessing the

[96] See Eriksson (1993: 69-70, 95-97) for a discussion of the Kom Rabi'a Red Lustrous Wheel-Made Wares.

percentage of imports relative to the local pottery. This is important for understanding the significance of the Canaanite jars and their prevalence at the site, recalling that the small houses indicate a population of low to middle class individuals possibly lacking access to imported commodities. The frequency of Canaanite jar rim sherds within the sampled pottery was always less than 1% (Table 3.2)[97]. However, within the imported pottery, the Canaanite jar sherds are easily the dominant class (Bourriau 1990b: 19*). When the percentage of Canaanite jar sherds is compared by level, there is a peak in numbers from the early to mid 19th Dynasty (Fig. 3.8). However, the Canaanite jar fabric types remained relatively the same throughout the New Kingdom, and were recognized in a few sherds found in the post-New Kingdom levels (Aston & Jeffreys 2007: 27-29, 32, 37, 38). Furthermore, vessels with similar rim, base, and handle types occured in several fabrics, suggesting that different manufacturers were producing vessels with a nearly identical shape (Bourriau 1990b: 20*). The fabrics themselves showed noticeable variation resulting in their classification into seven fabric groups (Table 3.3). The rare fabrics included P16 and P30, while P11, P31 and P33 fabrics were more common.

Table 3.2: Relative frequency of Canaanite jar sherds in the Kom Rabi'a levels

| **Level** | **Percentage of CJ rim sherds in random sample** | **Date** |
|---|---|---|
| IIa | 0.5% | Mid-Late 19th Dynasty |
| IIb | 0.7% | Early-Mid 19th Dynasty |
| IIIa | 0.3% | Late 18th Dynasty – Early 19th Dynasty |
| IIIb | 0.4% | Mid-Late 18th Dynasty |
| IV | 0.2% | Early-Mid 18th Dynasty |
| V | 0.2% | Second Intermediate Period – Early 18th Dyn. |
| VI | 0.4% | Mid-Late 13th Dynasty |
| VII | 0.4% | Mid 13th Dynasty |

[97] The New Kingdom percentages are from Bourriau; the Middle Kingdom/Second Intermediate Period percentages are from Gallorini.

Fig. 3.8: Numbers of Canaanite jar sherds in the New Kingdom levels

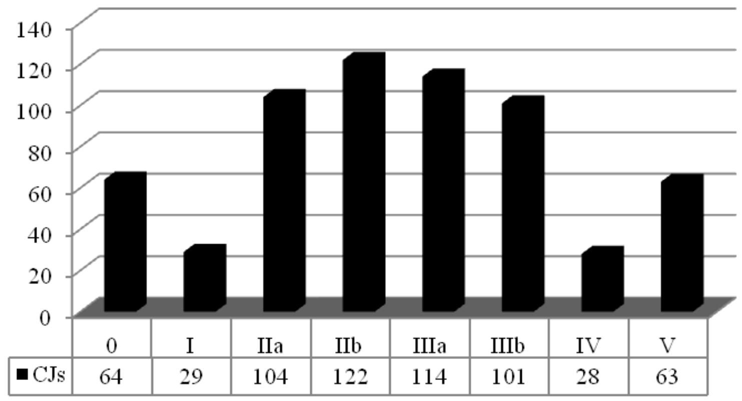



Table 3.3: Memphis New Kingdom Canaanite Jar fabric descriptions (from Bourriau 1990b)

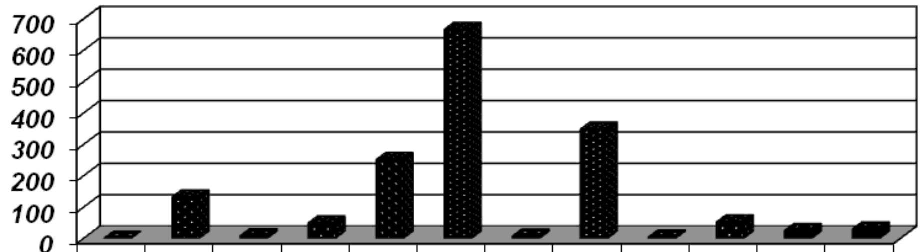
| Fabric | Inclusions |
|---|---|
| P11 | fine and coarse sand (fine grey-white, red-brown, and dark rock particles), and fine limestone |
| P16 | fine sand (coarse grey-white particles, fine and coarse dark rock particles), fine and coarse limestone, ochre, grog, and straw voids |
| P23 | fine sand (coarse grey-white particles and fine dark rock particles), fine to coarse limestone, and grog |
| P30 | fine and coarse sand (fine grey-white, red-brown, and dark rock particles), and medium to coarse limestone |
| P31 | fine sand (coarse grey-white particles, medium red-brown and dark rock particles), medium to coarse limestone, and shell |
| P33 | fine sand (fine to coarse irregular grey-white particles), mica, and shell |
| P40 | medium sand (coarse grey-white, red-brown and dark rock particles), medium to coarse limestone, mica, and shell |

For the Middle Kingdom levels, the highest frequency of Canaanite jar sherds occurred in Level VId at the beginning of the Second Intermediate Period (Fig. 3.9). Moreover, there was greater variety in the fabrics for the Middle Kingdom material, and more sherds were recorded than for the New Kingdom levels despite the smaller area excavated (Bourriau pers. comm.). The fabrics were classified into six groups, P100, P101, P102, P103, P104, and P105[98]. Three additional fabrics, P34, P42 and P43, were based on residual Canaanite jars found in the New Kingdom levels. When the numbers of sherds from each fabric group is calculated[99], the most common fabrics were P100, P102, and P103, while P101, P104, and P105 were rarer. Overall, Kom Rabi'a was characterized by a

[98] These groups are described in more detail in Chapter 5.
[99] Based on the database; P100=466 sherds; P101=293 sherds; P102=31 sherds; P103=624 sherds; P104=59 sherds; P105=23; and the few residual sherds P34=36; P42=24; P43=8.

predominantly Egyptian material culture with a few imported vessels, consisting mostly of Canaanite jars.

Fig. 3.9: Numbers of Canaanite jar sherds in the late Middle Kingdom and Second Intermediate Period levels (from Gallorini)




| | VIII | VII | VI-VII | VIe | VId-e | VId | VIc-d | VIc | VIb-c | VIb | VIa-b | VIa |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ■ CJs | 0 | 132 | 8 | 49 | 251 | 666 | 7 | 348 | 4 | 52 | 25 | 30 |

## *3.3. Canaanite Jars*

### 3.3.1. Definition, description, and technology

The term “Canaanite Jar” is applied to large two-handled vessels with an ovoid shape and restricted neck. They were typically utilized to store and transport goods from the 2nd to the 1st millennium BC in the Eastern Mediterranean. This name was applied to the vessels by Grace (1956) as a way of making their origin definitive. Although the development of Canaanite jars from Early Bronze Age storage jars in Syria-Palestine is likely, the precise antecedents are somewhat uncertain (Parr 1973) [100]. Gerstenblith (1983: 63) identified the origin of the Canaanite jar in the painted storage vessels without handles (classified as Habur ware) found in the Levant and dated to the early MB I (MB IIA in the system used in this thesis; Fig. 3.10)[101]. Vessels of this type appear slightly earlier at sites in Syria and Cilicia; some feature two handles, possibly implying that this area influenced those found further south[102]. The discovery of two handled jars in the Chamber of Offerings at Byblos, dated to MB I (MB IIA), suggests their presence during this period along the northern coastal Levant (Thalmann 2008: 67). These jars are slightly different in form from the contemporary domestic jars at the site of Tell ‘Arqa, signifying that within the MB I (MB IIA), regional

[100] Parr (1973: 179-180) sees the origin of the MBA Canaanite jars in storage jars found in southern Mesopotamia.
[101] Within the Levant, the Canaanite jars are discussed as storage jars whether they are of the “Canaanite jar” shape or not. For the current discussion, the chronological system (see discussion in section 2.3.1) used by the excavators for each site has been employed, with the system used in this thesis in brackets for each case.
[102] Gerstenblith (1983: 62, 64) sees the appearance of handleless painted store jars in Mesopotamia as occurring after they appear in the Levant.

traits existed. The similarities between the MB I (MB IIA) material in Palestine and the ceramic corpora at sites in the north such as Hama and Qatna suggests pottery developments in the north are likely to have influenced the shapes of vessels in the south (Amiran 1960). As the MB I (MB IIA) period progressed, the jar shape acquired the characteristic Canaanite form with two handles, shorter neck, and a more tapering body (Gerstenblith 1983: 78). In particular, the Tell ‘Arqa jars appear to have developed from the locally produced handled domestic jars of the MB I (MB IIA), whose origins may relate to the ceramic repertoire of the northern Levant or north Syria (Fig. 3.11; Thalmann 2002: 376, 2003: 28). Most likely, the form appeared at a few probably coastal sites early in the MBA, and was adopted by other sites as their participation in trade increased. (see Fig. 3.12 for location of sites discussed in this section and the ones below)

Fig. 3.10: Painted handless and handled store jars from Aphek (Gerstenblith 1983: Fig. 19)

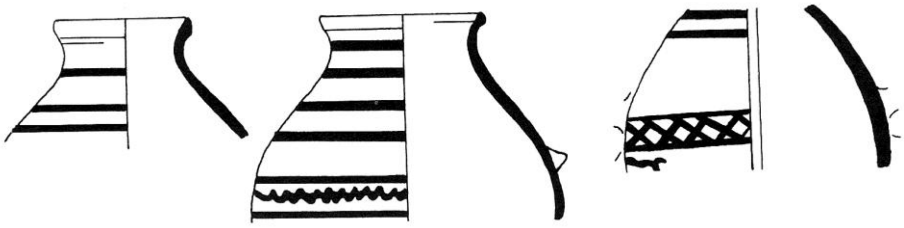


Fig. 3.11: Storage jars from Tell ‘Arqa, late EBA to MBA (Thalmann 2003: Figs. 6, 10, 15, and 16)

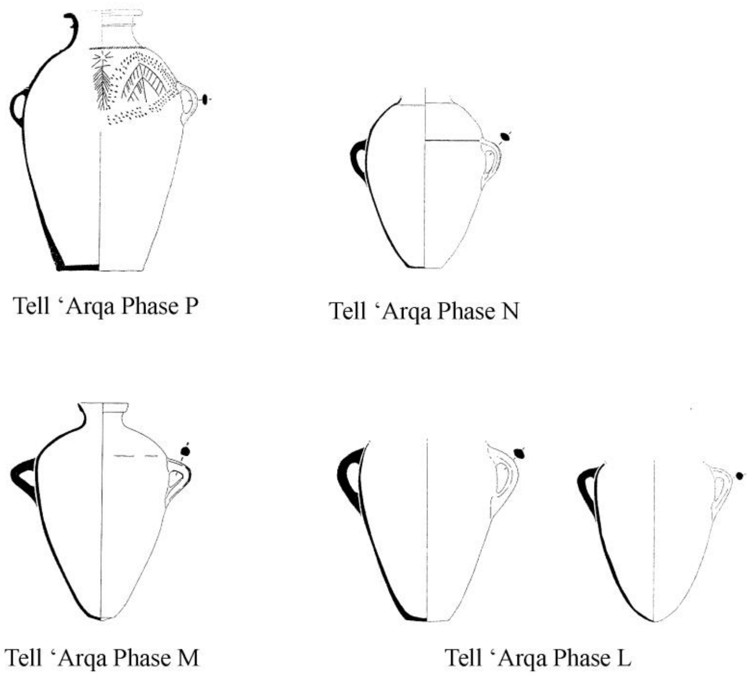
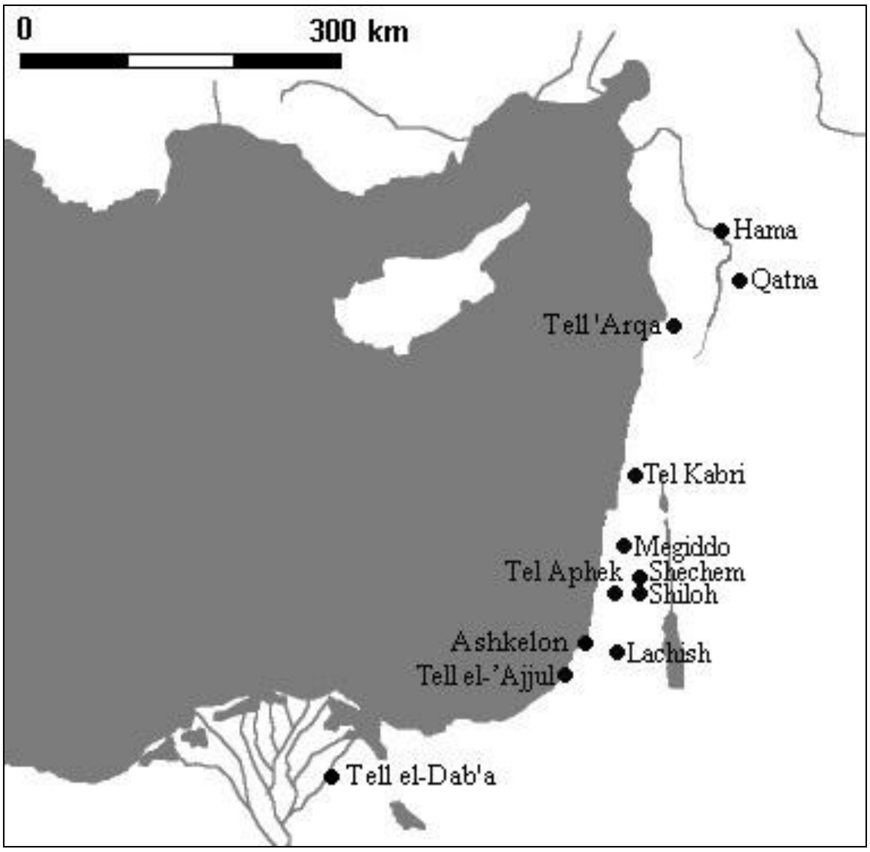


Fig. 3.12: Sites mentioned in the text for Canaanite jar development




The standard MBA Canaanite jar form exhibits a flat to slightly rounded base, ovoid body, two vertical handles at the maximum diameter of the vessel, gentle-curving shoulder, short concave neck, and typically, an outcurved rim (Fig. 3.13; Amiran 1970: 102-103, Plate 31; Aston 2002: 44). However, the rims show great variation chronologically and within periods[103]. MB I (MB IIA) Canaanite jar rims at Lachish feature a ridge (Fig. 3.14; Singer-Avitz 2004: 996)[104]. In the MB IIA levels at Aphek, the rims in the early phase have a triangular section, while in the later phases the rims change from being mostly an elongated fold with no ridge below, to those with a noticeable ridge below the fold (Fig. 3.15; Beck 1985: 186, 192, 194; Kochavi & Yadin 2002: 223). From the Tell el-Dab$^c$a MB IIA material, three rim types occured together in the levels: the incurved and slightly thickened rim, the everted folded rim with a defined or undefined lower edge of the fold, and the thickened

[103] Problems in examining the shape developments of the Canaanite jars include: chronological issues (discussed in Chapter 2); terminological problems in identifying "Canaanite jar" types from the listed storage vessels; complete examples deriving mostly from tombs; and no discussion of fabric, which causes uncertainty as to whether the vessels are local (if the site did indeed manufacture transport jars), imports, or a mixture of both. For understanding chronological changes in these jars, their shape would have to be related to differences in fabric.

[104] The scale has been left off of the figures as often the original images lacked a scale or the drawings used a variety of scales. As a guide, the MBA Canaanite jar rims are between 10 and 15 cm. in diameter.

strongly everted or flaring rim (Fig. 3.16; Aston 2002: 45, 67-71). The later MB II (MB IIB) rims at Lachish lack the ridge and are thickened and everted, ring-shaped, or have an inner gutter (Fig. 3.17; Singer-Avitz 2004: 904, 914, 918). The MB IIB and MB IIC vessels from Shechem show that the elaborately profiled rims are more common in the later strata, whereas the everted rims are the norm for the MB IIB levels (Fig. 3.18; Cole 1984: 73-75). The excavated jars at Shiloh indicate the ridged rim appears more common in MB II (MB IIB), being slowly replaced by a flared rim and a rilled rim in MB III (MB IIC) (Fig. 3.19; Bunimovitz & Finkelstein 1993: 91). The Second Intermediate Period vessels at Tell el-Dab[c]a feature simple direct rims or more complex types (Fig. 3.20; Aston 2004a: 239-240).

Fig. 3.13: Typical MBA Canaanite jar form (Tufnell 1962: Fig. 10)

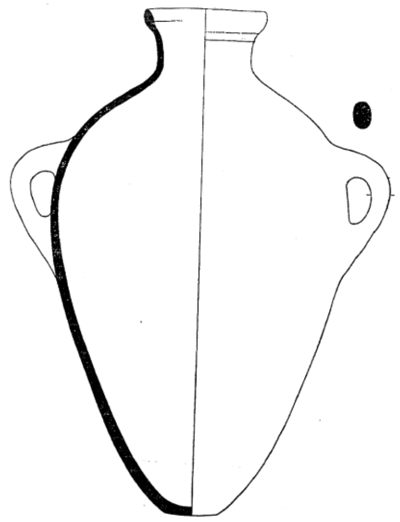


Fig. 3.14: MB I (MB IIA) storage jar rims from Lachish (Singer-Avitz 2004: Figs. 16.4 and 16.10)

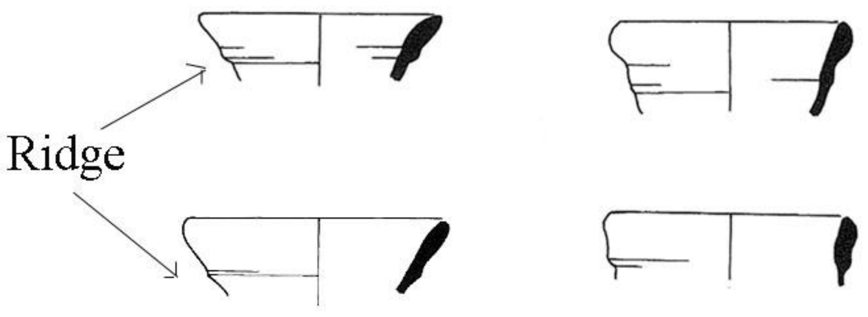


Fig. 3.15: MB IIA storage jars rims from Aphek (Beck 1985: Figs. 2, 4, and 5)

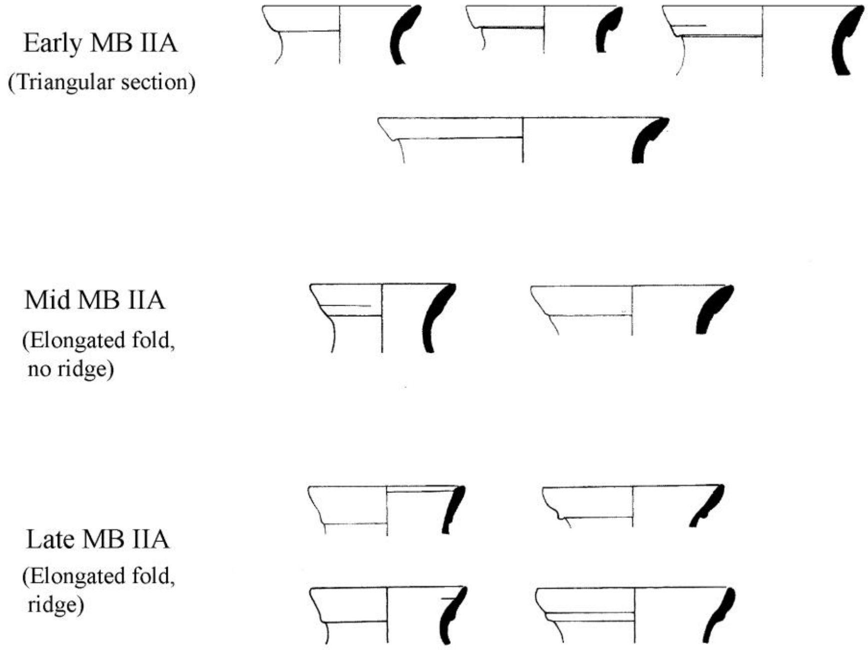



Fig. 3.16: MB IIA Canaanite jars from Tell el-Dab$^{c}$a (Aston 2002: Figs. 5-6, 8)

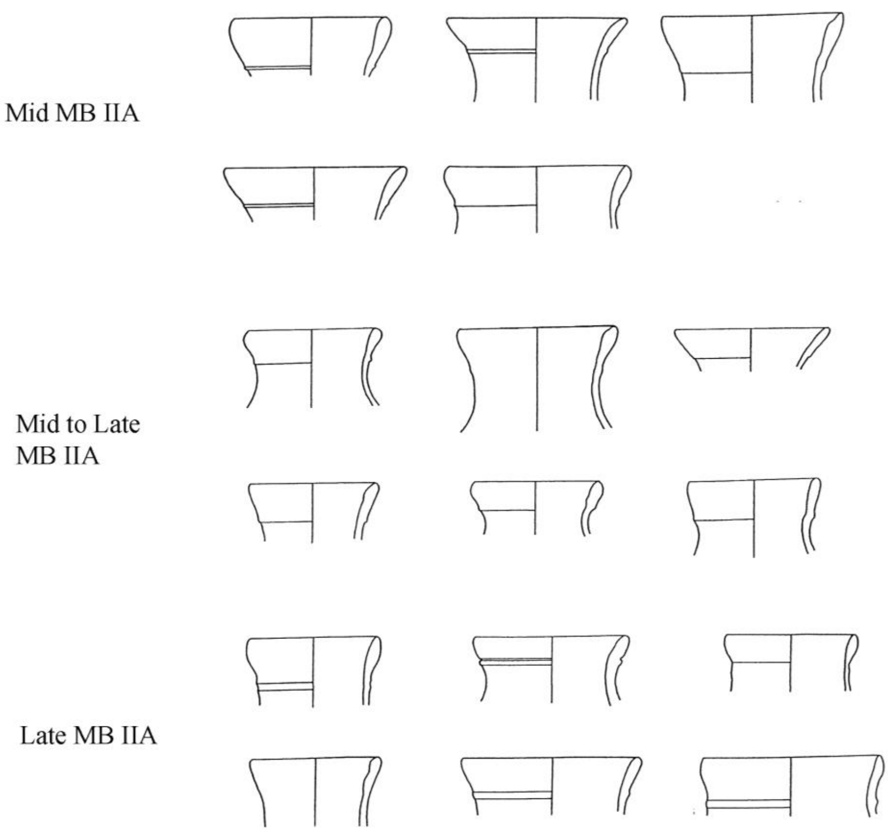


Fig. 3.17: MB II (MB IIB) storage jars from Lachish (Singer-Avitz 2004: Figs. 16.17, 16.27, and 16.32)

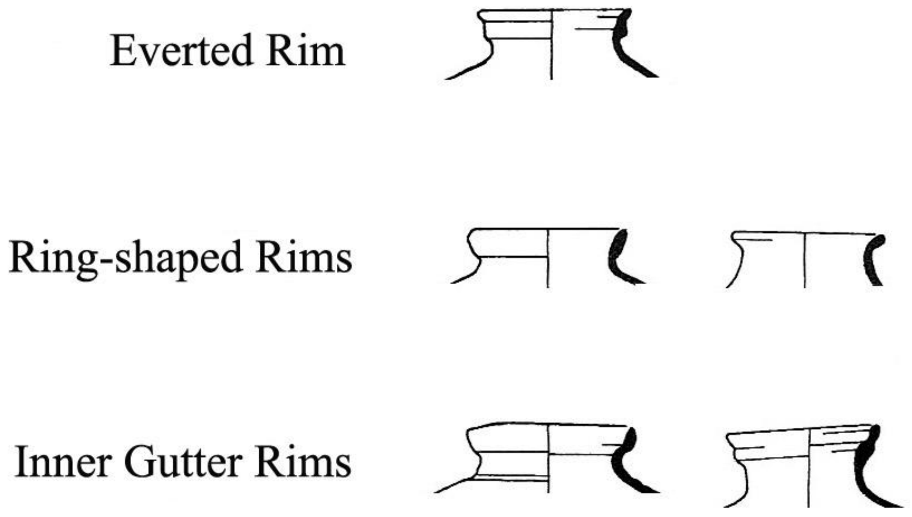



Fig. 3.18: MB IIB and MB IIC storage jar rim types from Shechem (Cole 1984: Plates 32-36)

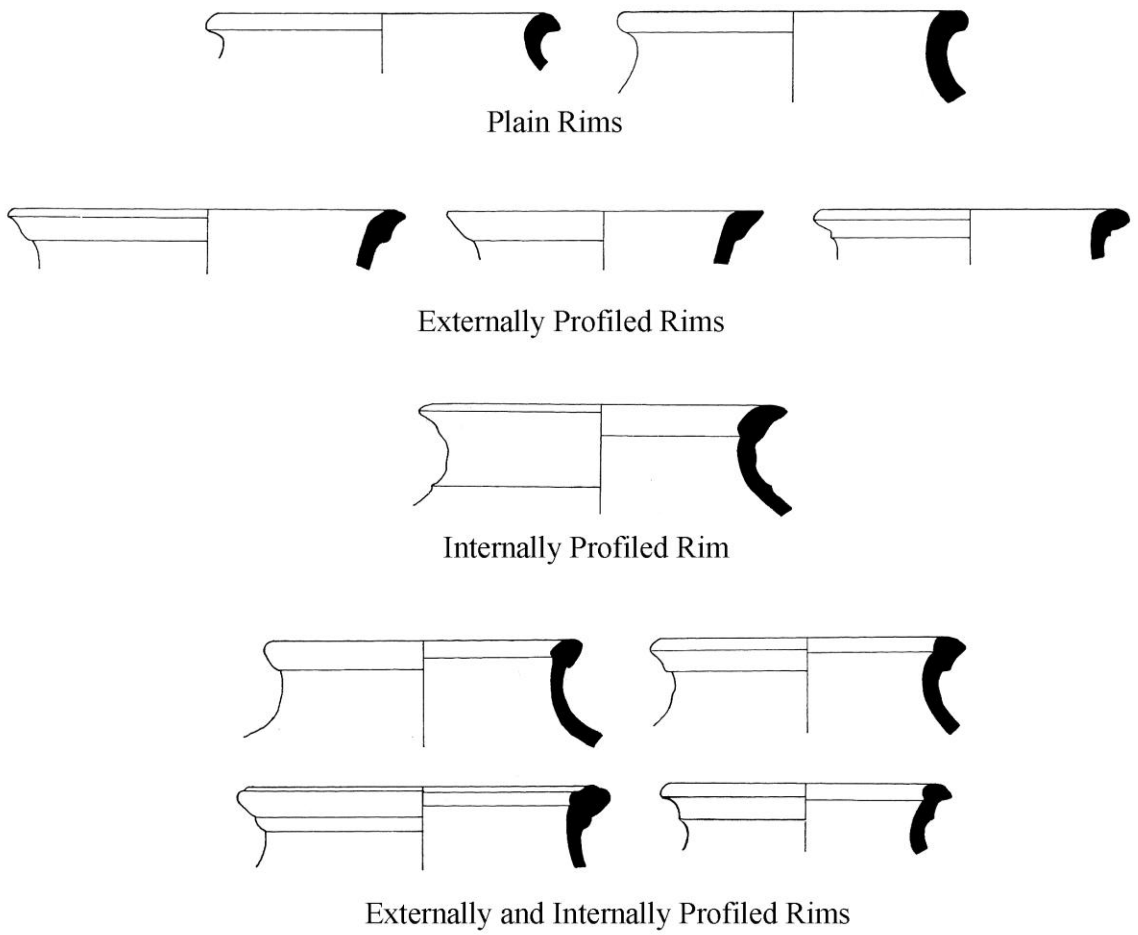


Fig. 3.19: MB II (MB IIB) and MB III (MB IIC) storage jar rims from Shiloh (Bunimovitz & Finkelstein 1993: Figs. 6.7, 6.9, and 6.23)

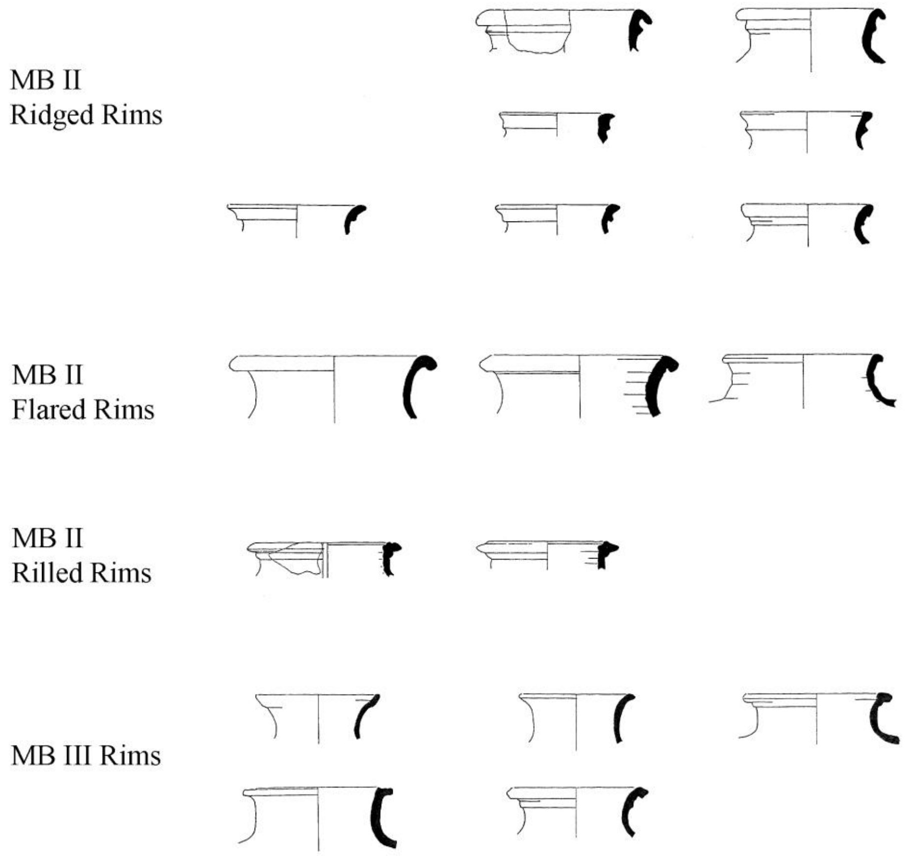



Fig. 3.20: SIP Canaanite jars from Tell-Dab$^{c}$a (Aston 2004a: Plates 284-287)

Changes in Canaanite jar bases in the MBA are seen in the sequence of MB IIA vessels at Aphek. Over time, the flat bases become narrower (Beck 1975: 52, 1985: 186, 192, 194), a development confirmed by the jars from Tell el-Dab$^{c}$a (Aston 2002: 59-65). Both the MB I (MB IIA) and MB II (MB IIB) jars from Lachish feature round and flat bases (Singer-Avitz 2004: 904, 914, 918, 996). Jar bases from Shechem are flat or slightly convex during both the MB IIB and MB IIC (Cole 1984: 775-76). The bases of Shiloh MB III (MB IIC) jars are flat and narrow, while later examples are even narrower (Bunimovitz & Finkelstein 1993: 91). These differences can be difficult to see in line drawings, and the variation in base form appears slight. Similarly, the shoulders of these jars appear rounded with little variation. The handles on jars at Tell el-Dab$^{c}$a seem to shift higher on the body by the Second Intermediate Period (Aston 2004a: 240). However, these features, along with handle shape, are rarely discussed in publications of storage jars.

Concerning technology of production, the early MBA jars from Tell ‘Arqa appear to be coil built with only the neck and rim finished on the wheel (Thalmann 2002: 370). Most of the MBA Canaanite jars studied by Parr (1973: 174, 178) appeared to be wheel-made. Some featured marks on the exterior surface of the body consistent with scraping to thin the vessel walls. A similar manufacturing technique is evident on the vessels at Tell el-Dab$^{c}$a (Aston 2002: 44, 2004: 163). The bodies could be decorated with a combed pattern, known already on jars in the EB II period, but continuing in use into the MB II (MB IIB) period (Amiran 1970: 59, 66-67, 103; Finkelstein *et al.* 2000: 199; Beck 2000: 177; Aston 2002: 44; Thalmann 2003: 27-28, 32). However, in the MB I (MB IIA) and MB II (MB IIB) periods this combing is much lighter, particularly on jars from Tell ‘Arqa and Beirut (Thalmann 2008: 67). Additionally, in the early MBA, clay bands with decoration such as incising were applied to the region where the neck and shoulder join (Beck 2000: 115, 177; Thalmann 2003: 32). The height of the vessels ranged between 40 and 70 centimetres.

Morphological changes from the typical MBA form to the LBA Canaanite jar type occurred gradually, with additional developments taking place during the LBA (Fig. 3.21; Grace 1956: 87-88; Amiran 1970: 141-142). The excavated strata at Megiddo provide a developmental sequence for complete jars from the MBA to the LBA, although this applies only to jars from this site that could be locally produced, imported or both (Fig. 3.22; Loud 1948)[105]. Bases that were originally flat and narrow have a more pronounced point or stump by the LB II/Amarna period (Fig. 3.23; Aston 2004a: 176-184). Over time, this stump base became wider, and probably served as an additional handle to grasp the vessel for transport or for emptying the contents. Likewise, the body changed from an ovoid shape to one that is triangular. Contemporary with the base change, was the appearance of a tapered shoulder as opposed to the earlier round shoulder with a continuous join to the body. The shoulder continued to change, going from a sloping variety at the end of the 18$^{th}$ Dynasty to a virtually horizontal type, associated with a longer body, by the reign of Ramesses II in the 19$^{th}$ Dynasty (Fig. 3.23; Aston 2004a: 176-184). As the shoulder changed, the placement of the vertical loop-shaped handles also altered from slightly above the maximum diameter of the body to the join between the body and shoulder. The complete vessels from Lachish show

[105] The similarities in form for the jars from Strata XII to IX are probably the result of applying simplified types to the vessels by the excavator.

the shapes common from the second half of $13^{th}$ century (Level VIIA) to the first half of the $12^{th}$ century (Level VI) (Fig. 3.24; Yannai 2004: 1048, 1053, 1062). The concave neck of the vessels became longer over time, although there is some variability in its precise form. A change in the rims appears in the early part of the LBA, with the new types lacking the inner gutter and featuring a less pronounced exterior roll (Fig. 3.25; Yannai 2004: 1042). Different rim types are also found on jars dated to the middle of the LBA (Fig. 3.26). The height of the vessels ranged from 50 to 60 centimetres, although there were smaller versions.

Fig. 3.21: Chronological development of LBA Canaanite jars within Palestine (Amiran 1970: 139, Plate 43)

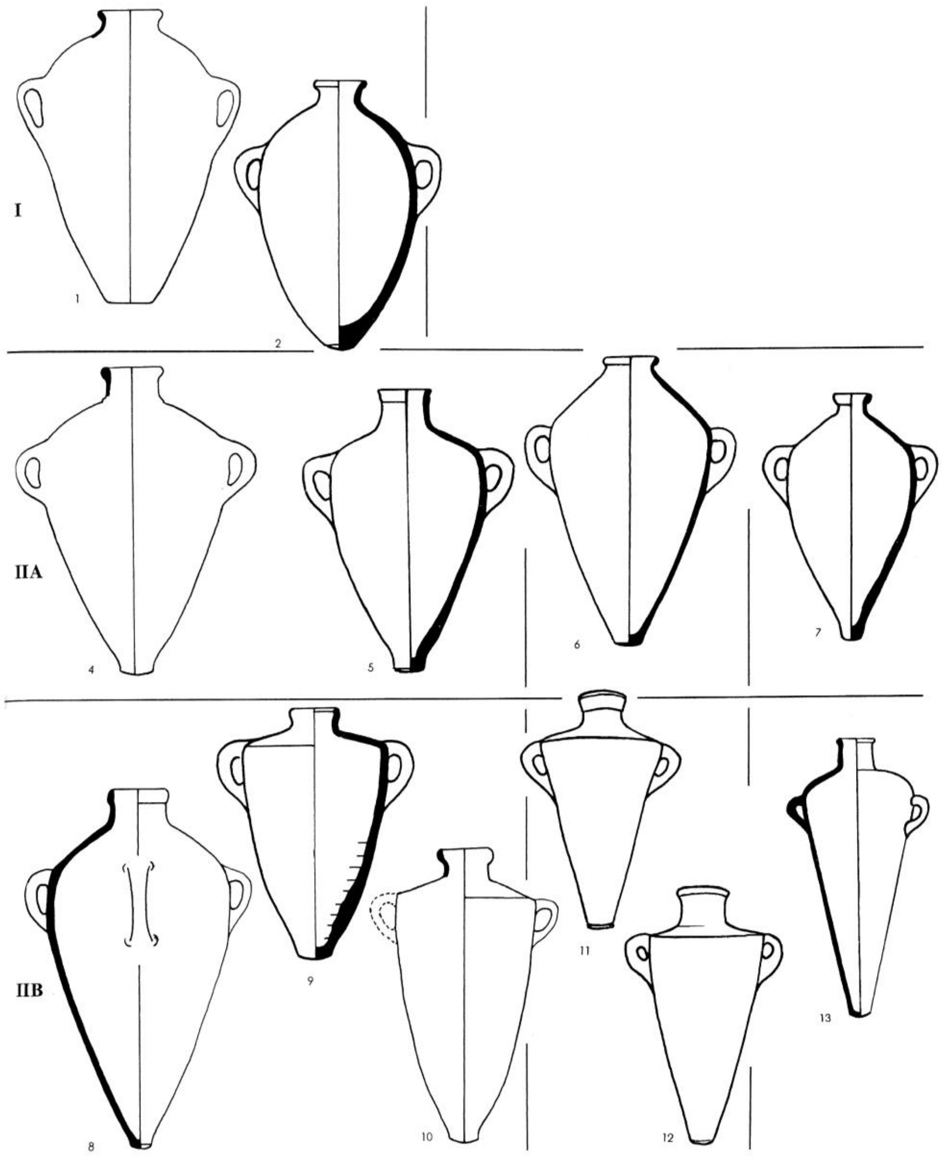


Fig. 3.22: Chronological development of MBA and LBA storage jars from Megiddo (Loud 1948: Plates 16, 18, 27, 35, 42, 51, 59, and 64)

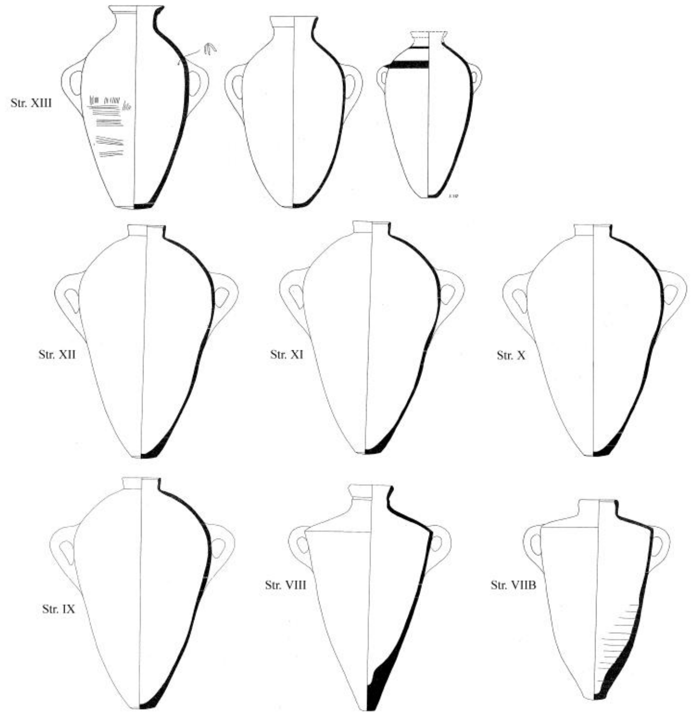



Fig. 3.23: Chronological development of LBA Canaanite jars as seen from Egypt (from Aston 2004a: Figs. 1-3)

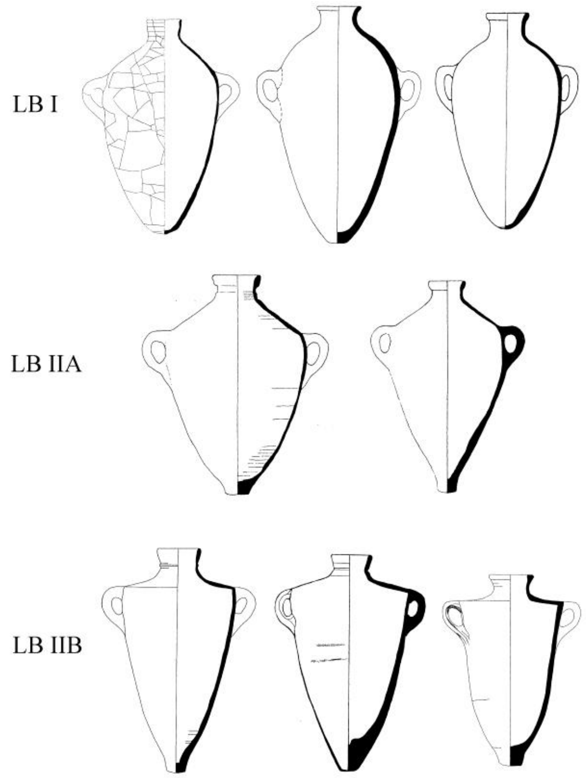


Fig. 3.24: LBA storage jars from Lachish (Yannai 2004: Figs. 19:33, 19.35, 19.45, and 19.50)

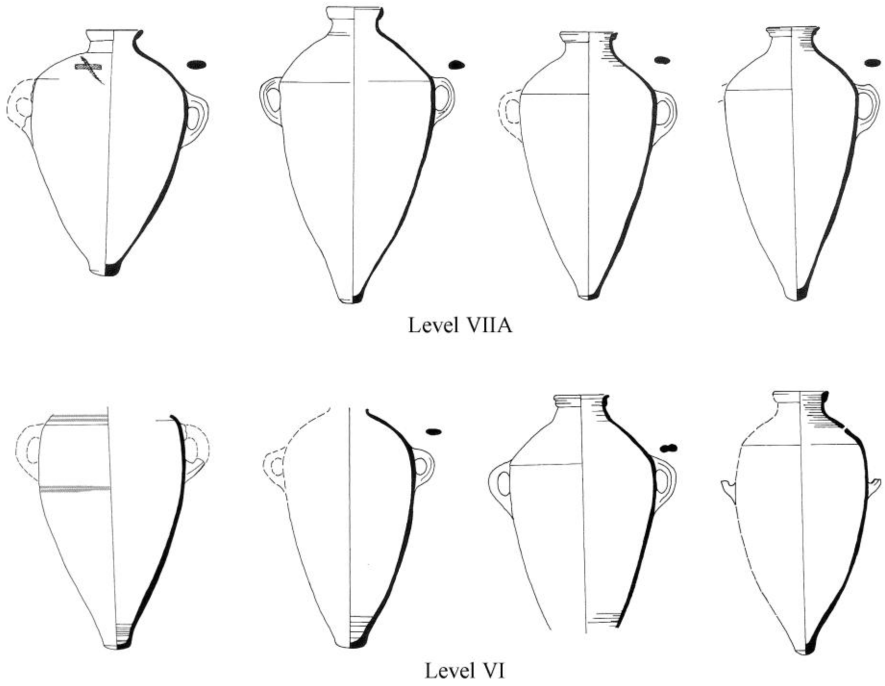



Fig. 3.25: Early LBA storage jar rim types from Lachish (Yannai 2004: Figs. 19.4 and 19.8)

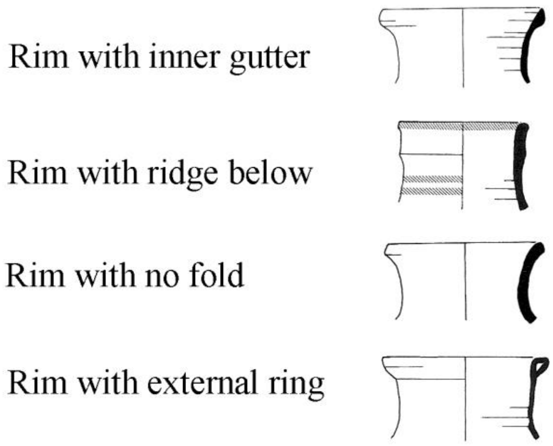
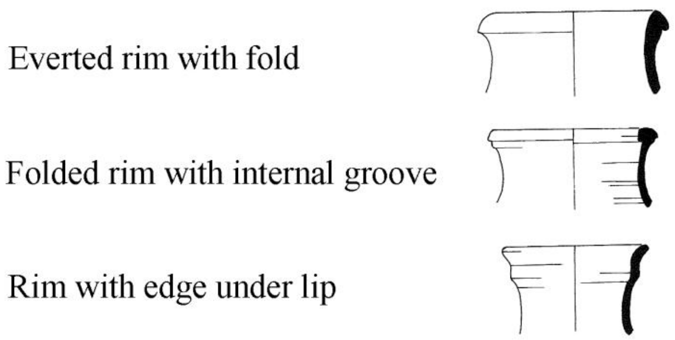



Fig. 3.26: Mid LBA storage jar rim types from Lachish (Yannai 2004: Fig. 19.15)



Rye (1981: 134-137) investigated the manufacturing technology of LBA Canaanite jars from Palestine. Most vessels had been made on the wheel and the walls were thinned by scrapping. The base was typically finished on the wheel by placing the vessel upside down. Next, handles were applied and the vessel exterior smoothed, or in some cases coated with a slip. Examination of LBA Canaanite jars from Amarna suggested that the vessels were wheel-made in several sections, while the base was moulded (Rose 2007: 147-149). However, once the base had been attached, the vessel was returned to the wheel and the join smoothed. Another LBA Canaanite jar from Amarna featured a handmade body, probably made by coiling, and a rim, neck, and shoulder thrown on the wheel. Some vessels included marks on the exterior walls suggesting scraping was used to thin them. Often the vessel exterior was smoothed vertically (Bourriau *et al.* 2005: 72-75; Rose 2007: 148-149). Rarely, some of these vessels were painted with an Egyptian-style flower motif, with examples known from Malkata and Amarna (Hope 1989; Rose 2007: 148).

### 3.3.2. History of study

While excavation reports often contain information regarding the Canaanite jars recovered, until recently, little attention was given to the jars themselves. The presence of vessels in Egypt was first noted by Montet (1928: 199-200, plates CXVI and CXVIII), during a discussion of MBA Canaanite jars in the Royal Tombs at Byblos. Further, Montet (1937: 50-51) related these vessels to images of similarly shaped jars in New Kingdom tombs at Thebes (see below). The first thorough discussion of Canaanite jars was undertaken by Grace (1956) who examined LBA examples found in Greece. Their production throughout Syria-Palestine and distribution from this area was noted, along with the identification of Egyptian versions (see also Grace 1961: 6-8). A chronological study by Amiran (1970: 140-142, Plate 43) illustrated the changes in vessel form in LBA Canaanite jars found in Palestine. However, Amiran did not discuss the development of the MBA Canaanite jars from earlier storage jars in the Levant, a topic covered by Parr (1973).

Zemer (1978) described the Canaanite jars found off the coast of Israel and stored at the National Maritime Museum in Haifa. This work emphasized the importance of the vessels for transporting commodities around the Eastern Mediterranean from the Late Bronze Age to the early Arabic Period. More recent work has also considered Canaanite jars in the context of trade, particularly of wine, in the Eastern Mediterranean (Leonard 1995). Thalmann's (2003) examination of Canaanite jars from the Early Bronze to the beginning of the Late Bronze Age at Tell ʿArqa has provided information on their capacities. A comparison of Tell ʿArqa jars with those from Sidon and Tell el Ghassil showed that the characteristic transport jar of 25-30 litres was missing from the latter sites (Doumet-Serhal and Griffiths 2003). Finally, the corpus of Canaanite jars found in Egypt in the New Kingdom was discussed by Aston (2004).

While these studies have provided information on the shape and distribution of Canaanite jars, scientific studies have sought to characterize the materials used and to locate areas of production. The first scientific analysis of Canaanite jars was carried out by Raban (1980) who employed Instrumental Neutron Activation Analysis (INAA) to examine vessels from a number of sites in the Levant, Cyprus, and Greece (Åström 1986: 65; Jones 1986: 571-573; Leonard 1995: 249)[106]. Marcus (1995) conducted a petrographic study of the MB IIA Canaanite jars from Tel Nami, which helped to characterize their probable local fabric. Griffiths (2003) analyzed through petrography several MBA Canaanite jars from Sidon and described the materials used. Within Egypt, LBA Canaanite jars from Amarna were examined by petrography to confirm the fabric groups identified macroscopically (Nicholson and Rose 1985). More recently, the LBA Canaanite jars from Memphis, Amarna, and Saqqara were examined by thin section and chemical compositional analyses to determine their provenance (Smith *et al.* 2000; Bourriau *et al.* 2001; Serpico *et al.* 2003; Smith *et al.* 2004). A large petrographic study of MBA Canaanite jars and other imported vessels from Tell el-Dab$^{c}$a was carried out by Cohen-Weinberger & Goren (2004). This thin section study was a response to the NAA of imported material from Tell el-Dab$^{c}$a by McGovern (2000; McGovern & Harbottle 1997) in which the comparative samples used had not been proven as local to the sites from which they derived.

Several scientific studies have examined Canaanite jars outside of Egypt and the Levant. NAA performed on a Canaanite jar from Enkomi suggested it was manufactured at Ashdod in southern Palestine (Gunneweg *et al.* 1987). However, the exact form and date of the vessel has been questioned (Mazar 1988). Petrographic analysis would be useful to confirm these results since the illustrated vessel appears similar in shape to New Kingdom Egyptian amphorae. Jones and Vaughn (1988: 386-398) carried out thin section analysis, supplemented by Atomic Absorption Spectroscopy, on LBA Canaanite jars from the site of Maa-*Palaeokastro* in Cyprus. These analyses identified several imported types and a possible local variant. Finally, LBA Canaanite jars from Hala Sultan Tekke were investigated through instrumental micro colour analysis of their surfaces (Fischer 1991).

[106] The original work was written in Hebrew, so secondary sources are cited.

### 3.3.3. Evidence for their use

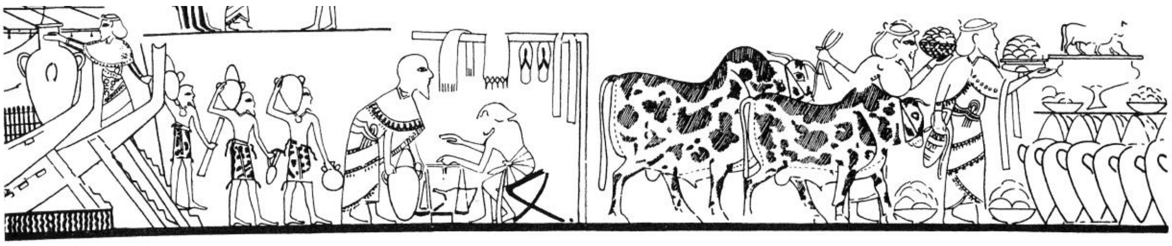
The function of Canaanite jars is suggested by their form. The shape of the vessels, the presence of two handles, and a restricted neck all indicate that Canaanite jars were used for storage; a conclusion supported by their similarity to other storage jars (Amiran 1970: 58, Plate 15; Parr 1973; Thalmann 2003). However, the change in shape between the EBA and MBA jars suggests that some began to be produced specifically for transport. Thus, the jars slowly evolved up to MB II (MB IIB) with bases becoming more pointed, a narrower body, handles placed higher on the shoulder, and an elongated neck (Amiran 1970: 141; Thalmann 2003: 35-36). The pointed base made vessels more manoeuvrable and stronger by evening out their weight, rather than focusing it on the join between body and base (Parr 1973: 177). The shape was also suitable for stacking in store rooms, leaning against a wall, or placing in a jar stand. By the LBA, the handles were placed at the shoulder, which had become almost vertical, and the body was now triangular. These features allowed the vessels to be more easily moved and stacked for storage, as seen in the storeroom at the port of Ugarit, and for placing upright within the cargo hold of a ship (Fig. 3.27; Amiran 1970: 141-142; Schaeffer 1939: 30, Plate IX; Zemer 1978). These were specialized vessels utilized for transport by sea, as the numerous LBA Canaanite jars in the Cape Gelondiya and Uluburun shipwrecks illustrate (Bass 1973: 34; Pulak 1997: 240).

Fig. 3.27: Deposit of 80 LBA Canaanite jars found at Minet el-Beida, the port of Ugarit (Schaeffer 1939: Plate IX)

The narrow neck and opening of the jars suggests that they could be sealed to prevent the contents from spilling or evaporating. This is confirmed by the survival of clay stoppers and the discovery of jars with the neck broken off to remove the contents (Hope 1978: 8; Tallet 2003: 497). This phenomenon was seen in Egypt and for jars from tombs at Tell Abu Hawam (Anati 1959: 100, Fig. 7). However, LBA jars in the tombs at Akko and others from Tell Abu Hawam have intact necks and feature bowls placed upside down over the opening, showing that the contents were accessed repeatedly, using the bowl to prevent evaporation and/or contamination (Ben-Arieh & Edelstein 1977: 2, 10; Anati 1959: 94). The contents could be removed with dipper juglets; a vessel type commonly found with the jars in tombs such as those at Tell el-ʿAjjul (MBA; Tufnell 1962: 8) and Tell Abu Hawam (LBA; Anati 1959: 94).

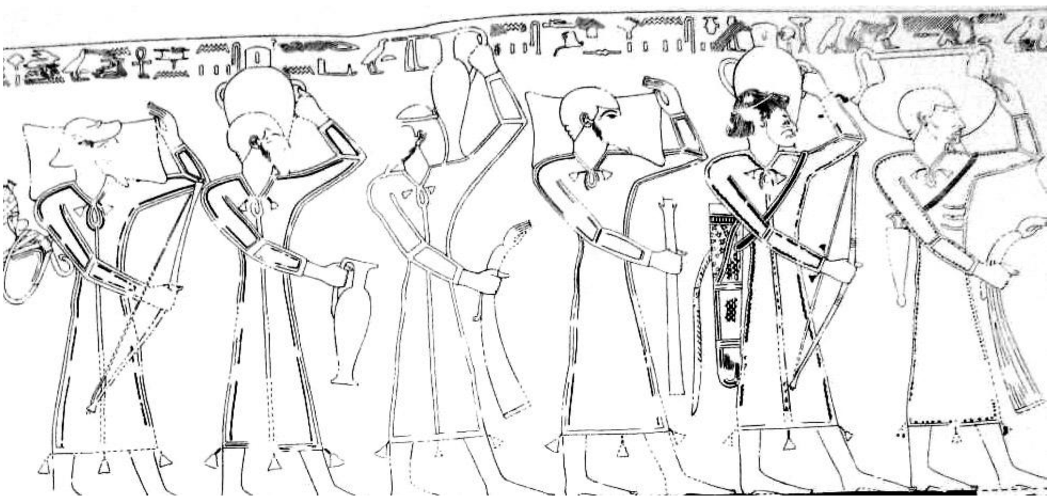
The movement and use of Canaanite jars in Egypt was illustrated in the tombs of New Kingdom nobles from Thebes. Theban Tomb (TT) 162, belonging to Kenamun and dating to the reign of Amenhotep III, shows Syrian merchants supervising the unloading of jars from a ship (Fig. 3.28; Davies & Faulkner 1947)[107]. This scene suggests the vessels arrived in Egypt through private traders. A scene in the tomb of Rekhmire (TT 100), Dynasty XVIII, shows foreigners bringing Canaanite jars as a part of tribute to the king (Fig. 3.29; Davies 1943: 28-30, Plates XXII-XXIII). The text above the scene suggests that the jars contained oil and *snṯr*, translated as incense, but does not name the country of origin (Davies 1943: 28-29). LBA Canaanite jars could also have been acquired on military campaigns, as shown in the 18th Dynasty tomb of Amenmose (TT 42), with an individual carrying a jar away from a captured city in Lebanon (Davies 1933: 30-31, Plate XXXVI). These scenes provide evidence for the various mechanisms through which jars could enter Egypt.

Fig. 3.28: TT 162 (Kenamun), scene of Syrian Traders unloading Canaanite jars (Davies & Faulkner 1947: Plate VIII)



[107] A similar scene of a Syrian ship in TT 17 belonging to Nebamun and also of 18th Dynasty date was badly damaged and poorly published (Davies & Faulkner 1947: 40, 45). None of Kenamun's many titles relate to foreign trade, although he appears to have accompanied the king on missions to the Levant and was an "Attaché of the King in Every Place" including foreign lands (Davies 1930: 12-13).

Fig. 3.29: TT 100 (Rekhmire), scene of foreigners carrying Canaanite jars (Davies 1943: Plate XXIII)



Once the jars arrived in Egypt, they were taken to several destinations, indicating that their contents were used for a variety of purposes. A scene from the tomb of Meryre I at Amarna shows the Magazines of the Royal Estate containing Canaanite jars, suggesting that the commodities they held were for royal consumption (Fig. 3.30; Davies 1903: Plate XXXI). Also at Amarna, a scene in the tomb of Meryre II illustrates the redistribution of the jars to the private sector (Fig. 3.31; Davies 1905: Plate XXXIII). In this scene, Meryre is being rewarded by the king with many different objects, including what appear to be Canaanite jars[108]. A scene in the tomb of Rekhmire (TT 100) shows Canaanite jars, labelled *snṯr*, stored as temple provisions, along with various other foreign goods (Fig. 3.32; Davies 1943: Plate XLVIII, Newberry 1900: Plate XIV). Interestingly, within the same scene, other jars are depicted in a storehouse with Egyptian objects, possibly suggesting that these jars were perhaps of Egyptian origin (see below). Additional scenes in the tomb show Canaanite jars being carried towards a temple storehouse, while in another scene the jars are being transported to a tomb (Davies 1943: 43-47, 70ff., Plates XLIX, L, XCII). Based on these scenes, Canaanite jars were utilized in the palace and temple, along with supplying the elite deceased with commodities important in the afterlife.

[108] This redistribution can be taken further at Amarna, since LBA Canaanite jars were found re-used to carry water to the Workmen's Village, see below (Renfrew 1987: 96-98; Rose 1987: 124-129).

Fig. 3.30: Tomb of Meryre I, scene of Canaanite jars in the Magazines of the Royal Estate (Davies 1903: Plate XXXI)

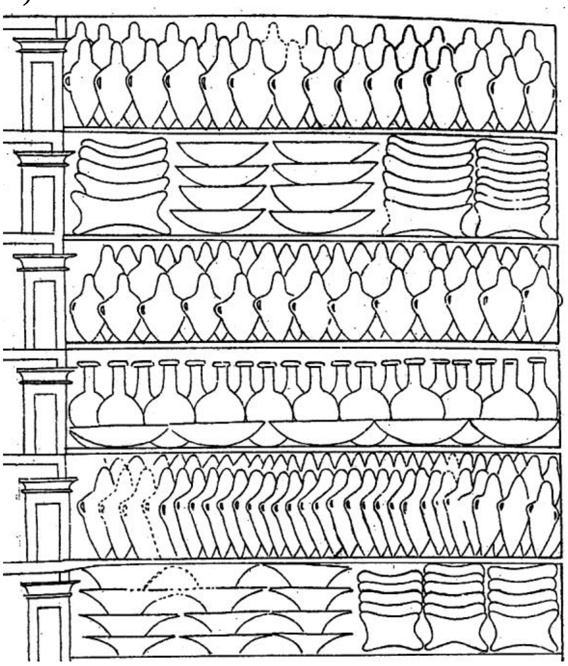


Fig. 3.31: Tomb of Meryre II, scene of reward showing Canaanite jars (Davies 1905: Plate XXXIII)

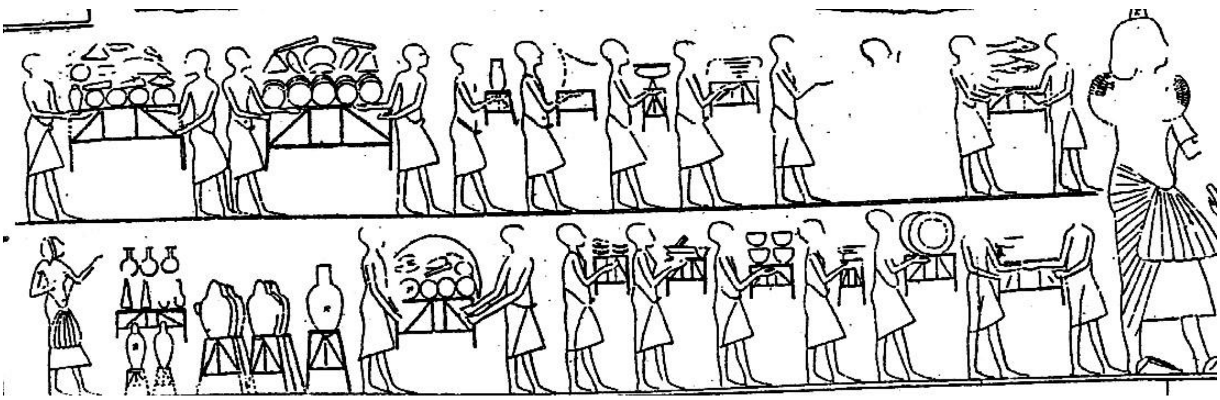
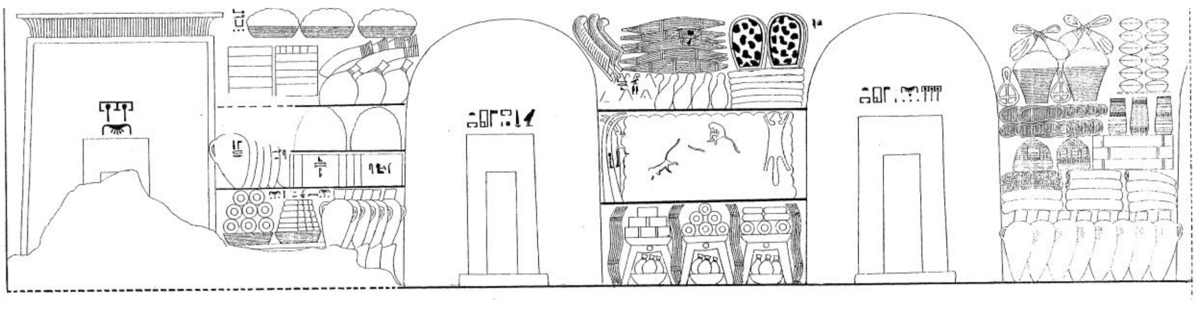


Fig. 3.32: TT 100 (Rekhmire), scene of Canaanite jars stored as temple provisions (Davies 1943: Plate XLVIII, Newberry 1900: Plate XIV)



Other scenes, such as one in the tomb of Apy (TT 217), dated to the 19th Dynasty, show Canaanite jars for sale at a market (Fig. 3.33; Davies 1927: Plate XXX). However, the identification of the vessels as imports is problematic since from around the mid-18th Dynasty, locally made amphorae became increasingly common (Hope 1989: 87; Bourriau 2004). Thus, despite the occasional variation in the depicted jar shapes within the same tomb (Davies 1927: Plate XXX), it remains difficult to determine if the artists would have distinguished between imported vessels and Egyptian amphorae, even though the latter could be of a distinctively different shape. This is illustrated in the wine-making scenes also from the tomb of Apy (Fig. 3.34; Davies 1927: Plate XXX, see also Davies & Davies 1923: Plate XXX and Davies 1943: Plate XLV). As Egyptians are shown in the process of making wine, the amphorae here are undoubtedly of Egyptian manufacture and have a characteristically slender form with a tall neck typical for the 19th Dynasty (Wood 1987: 79-81; Aston 2004b: 187-18). Although these tomb scenes present problems in the identification of foreign vessels, and the inscriptions do not mention the jars themselves, they still provide insight into how amphorae in Egypt were used.

Fig. 3.33: TT 217 (Apy), scene of a Canaanite jar at a market (Davies 1927: Plate XXX)

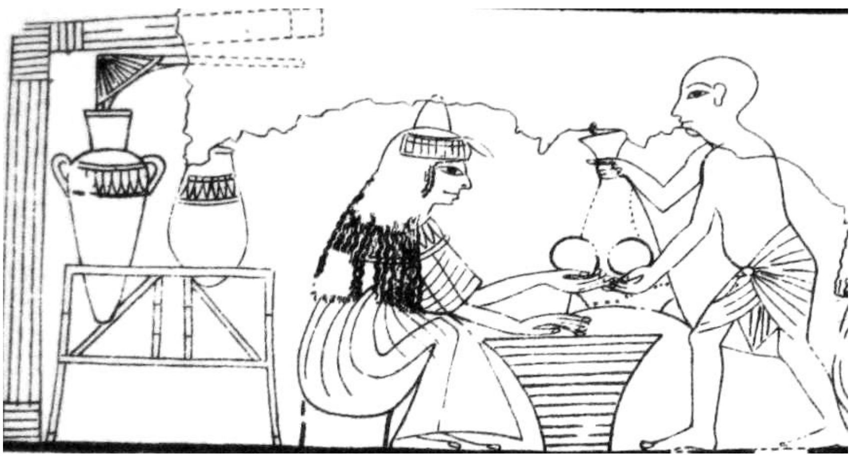
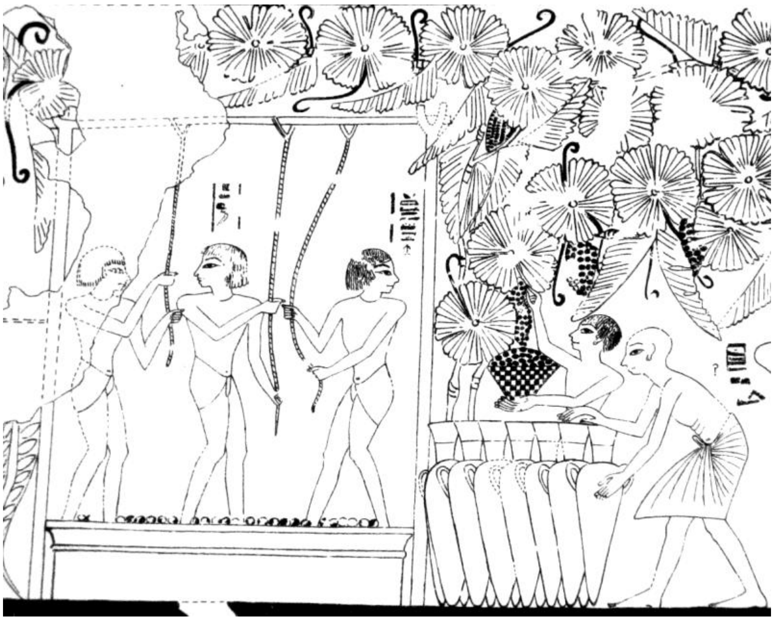
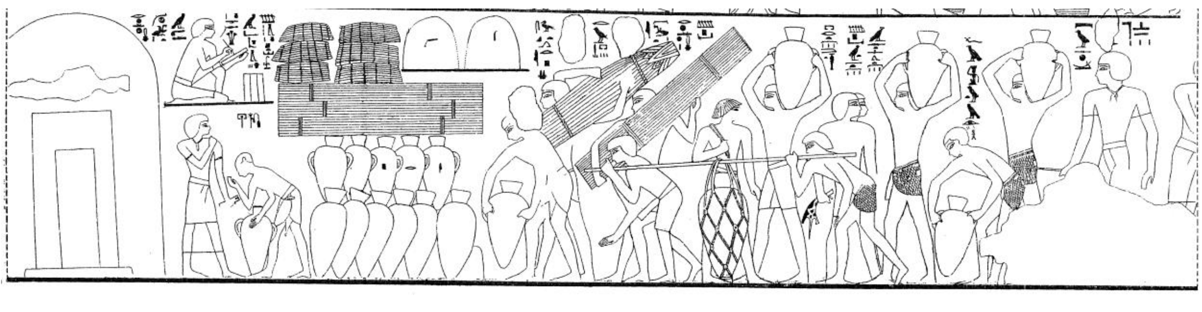


Fig. 3.34: TT 217 (Apy), scene of wine-making with probable Egyptian amphorae (Davies 1927: Plate XXX)



In some, but not all of these scenes, labels were written on the jars. The Canaanite jars stored in the temple depicted in the tomb of Rekhmire were labelled *sntr* (Fig. 3.32; Davies 1943: Plate XLVIII; Newberry 1900: Plate XIV). Another scene in the same tomb shows jars labelled *jrp*, translated as wine, being brought as temple provisions (Fig. 3.35; Davies 1943: Plate XLIX; Newberry 1900: Plate XII). Once again there is some uncertainty as to whether these are imported or local vessels. For the wine jars, however, the context suggests these are likely to be Egyptian, as wine in Egypt was known to be transported in vessels with similar shape, and the jars depicted are not connected to any other foreign individuals or goods[109].

Fig. 3.35: TT 100 (Rekhmire), scene of amphorae brought to the temple storehouse (Davies 1943: Plate XLIX, Newberry 1900: Plate XII)



[109] Evidence of the transport of wine in Egyptian amphorae was acquired by residue analyses (McGovern 1997; Guasch-Jané 2008). However, the method utilized by McGovern was problematic (see Boulton & Heron 2000: 600-602; Stern *et al*. 2008; Guasch-Jané 2008: 33-34, 61).

In addition to inscriptions on vessels in tomb scenes, preserved Egyptian hieratic labels written on Canaanite jars and seal impressions from the mud sealings placed over the rim and neck of the jars have been found (Leahy 1978; Hope 1978; Koenig 1979; Lecuyot 1997)[110]. Dockets are uncommon on vessels identified as imported to Egypt; those that have been found mention incense, several types of oil, and possibly wine[111] (Serpico 1996; Serpico & White 2000). LBA Canaanite jars sherds from Buhen appear to carry labels for *b3q* oil, *nhh* oil, and *snṯr*, although some of the labels were difficult to read (Serpico 1999: 269-272). Most likely these labels were applied after the jar entered Egypt, while the name of the king in the inscription may suggest that they were initially brought to the royal domain. The inscription mentioning *snṯr* also states the jar contents were for "The temple of Horus, Lord of Buhen" (Serpico 1999: 271). In addition to the tomb scenes, this suggests the utilization of imported incense during religious ceremonies. However, the presence of personal names in the Buhen jar labels indicates that the jars could be acquired by private individuals in addition to the temple and state. Recent re-examination of jar labels from Deir el-Medina confirmed that imported LBA Canaanite jars contained oil and incense (Tallet 2003). Jar sealings from the same site, produced of a non-Egyptian clay and attached to vessel necks of imported fabrics, confirmed that *b3k* and *nhh* oil were exported from the Levant (Tallet 2003: 497).

Since the jar labels listed the commodities carried, the possibility of confirming the presence of these goods through residue analysis was explored. The site of Amarna, located in a dry desert embayment, was ideal for the preservation of these residues within LBA Canaanite jar sherds (Serpico 1996; Serpico & White 2000)[112]. As New Kingdom inscriptions documented the importation of incense, *snṯr*, and oil, *nhh*, from Syria-Palestine, jars with these labels were analyzed (Serpico 1999: 271). Gas Chromatography-Mass Spectrometry (GC-MS) identified the resinous substances as *Pistacia* spp. resin[113], thus confirming the importation of this material and its use as incense. The identification of

[110] The identification of the vessels as imported or Egyptian is not stated in these publications. Lecuyot (1997) discussed vessel fabrics, which he divided into three groups, but does not state whether they are local or imports.
[111] Importation of wine from the Levant in LBA Canaanite jars is not confirmed by the labels, where the term *H3rw*, translated as "Syria", could be either the name of the vineyard, with Syria as a part, or the type of wine (Lesko 1995: 226). Another jar sealing from Buhen has been translated as "Wine of Syria", but only part of the label is preserved, while a jar inscription from the site may read "wine of Megiddo" (Smith 1976: 173, 177). Both translations are uncertain.
[112] The attempt to extract preserved residues from LBA Canaanite jars found at Memphis was not successful, due to the damp soil at the site encouraging post-depositional bacterial action that destroyed any organic remains. Therefore, the MBA Canaanite jars from Memphis were not tested for residue analysis (Bourriau pers comm.)
[113] Stern *et al*. (2008: 2188) caution against refining the identification of the resin to a specific tree species due to degradation of the residue and difficulties separating the signatures.

heated *Pistacia* spp. resin in Nile clay bowls near the Great Aten Temple established the use of this material in religious contexts (Stern *et al.* 2003). Moreover, analysis of residues found on objects in tombs and mummies suggests that the resin was also used during burial (Serpico & White 2001; Serpico & White 1998).

GC-MS analysis of residues in jars labelled *nhh*, and of a different fabric from those carrying incense, revealed that these jars contained oil (Serpico *et al.* 2003)[114]. Petrographic analysis, which suggested provenances for the jars, indicated areas along the northern coast of Palestine were exporting *Pistacia* spp resin, while manufacturers in Syria and Lebanon were exporting oil (Table 3.4). This is supported by the LBA Canaanite jars from the Uluburun shipwreck that contained *Pistacia* spp. resin and were of a similar fabric to those identified at Amarna as carrying resin (Mills & White 1989; Stern *et al*. 2008)[115]. Although the results imply a link between area of production of the jars and their contents, some of the jars manufactured along the coast of Palestine were also labelled with *nhh* and the word for honey, *bjt* (Serpico *et al.* 2003: 373). Therefore, while a certain locality may have principally exported one type of good, the same types of jars were occasionally used to transport a different commodity.

Table 3.4: LBA Canaanite jar petrographic groups, provenance, and identified residues (from Serpico *et al.* 2003).

| Group | Provenance | Residue |
|---|---|---|
| 1 | Haifa Bay | *Pistacia* spp. resin |
| 2 | Northern Coastal Palestine | *Pistacia* spp. resin |
| 3 | Akkar Plain | not analyzed |
| 4 | Syria | oil, possibly olive oil |
| 5 | Coastal Lebanon | oil, possibly olive oil |
| 6 | Cyprus | not analyzed |

An analysis of residues from MBA Canaanite jars from Tell el-Dab$^{c}$a was conducted by McGovern (2000: 74-77). Tartaric acid and calcium tartarate, the chemical signatures for grapes, were found in five of the twelve tested samples. Additionally, the residues in the same vessels had signatures for *Pistacia* spp.resin. This has been interpreted as evidence for the addition of resin to wine to control fermentation and influence the taste. However,

[114] The identification of a press for extracting olive oil at the site of Ras Shamra, and the similarity of the fabric between the jars carrying *nhh* oil and lamps from the site, may suggest that the oil transported to Egypt was olive oil.
[115] Although resinous material was the most common material contained in these vessels, other commodities were glass beads, orpiment, and olive pits (Haldane 1993: 352-353; Bass 1986: 278; Pulak 1997: 240).

vessels originally carrying resin may have been re-used to transport wine. NAA analysis suggested that some of the vessels with wine residue were produced in southern Palestine and Egypt. However, due to problems with the comparative material in the database[116], the question of the origin of these vessels must remain open. Unfortunately, these vessels were not examined petrographically by Cohen-Weinberger & Goren (2004).

The re-use of Canaanite jars has been noted in several cases. At Malkata, some vessels had a new label written over an older one (Hope 1978: 8)[117], while Canaanite jars at Amarna were re-used for carrying water (Renfrew 1987: 96-98; Rose 1987: 124-129). The tomb of Apy shows the lower half of a jar attached to a *shaduf*, a mechanism for lifting water (Fig. 3.36; Davies 1927: plate XXVIII). On Cyprus a LBA Canaanite jar was found re-used within a household context (Hadjicosti 1988: 361). MBA Canaanite jars were often re-used for child burials, as seen at Sidon, Hazor, Tel Aphek, Tell el-Dab$^{c}$a, and Tell el-Maskhuta (Doumet-Serhal 2004a: 116-117; Ben-Tor *et al*. 1997: 196-197; Beck 1975: 69; Bietak 1991a: 32, 41, 46; Redmount 1995b: 77). This practice appears to have continued into the LBA, with child burials in Canaanite jars seen at Enkomi on Cyprus (Åström 1991a: 149).

Fig. 3.36: TT 217 (Apy), scene of amphorae being used as a part of a shaduf (Davies 1927: Plate XXVIII)

[116] See Chapter 1.
[117] The jars in this example could either be imports or Egyptian amphorae.

### 3.3.4. Distribution

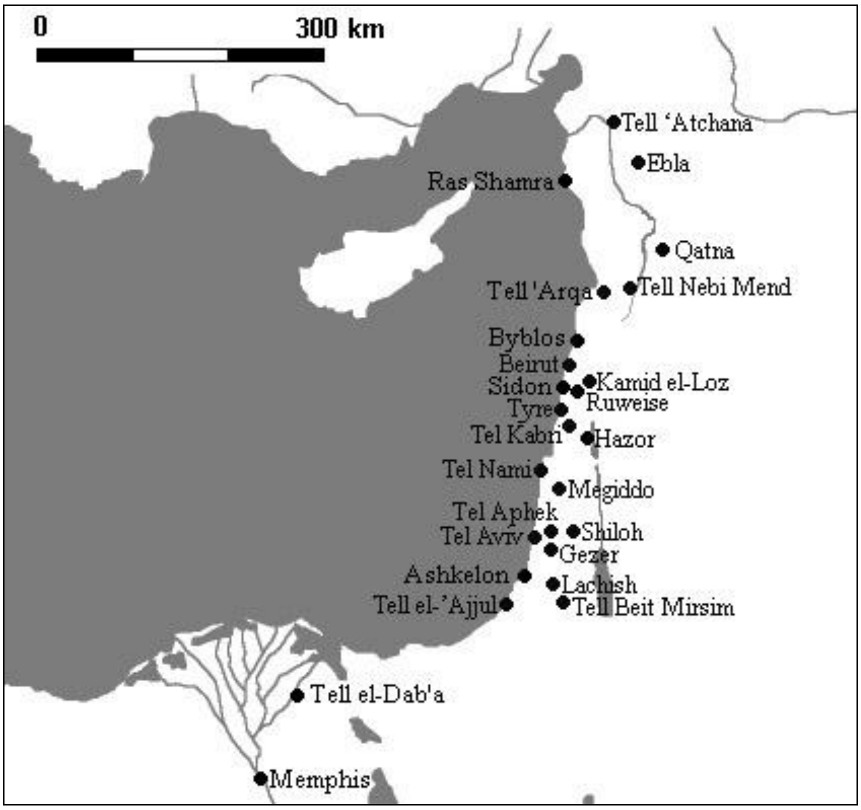
The distribution of Canaanite jars in the Levant is extensive. The presence of jars at large coastal sites is noticeable, especially during the MBA when they become more common. Their frequent occurrence at these sites provides clear evidence for their use in maritime trade. However, in examining their distribution, difficulties arise because older publications show only complete vessels, typically from tombs, while the sherd material from the settlements is not discussed. More recent publications (i.e. Megiddo, Aphek, Lachish, and Ashkelon) have presented the rims from storage jars[118]. However, these jars, and those in the earlier publications, are not distinguished as local (to the site) or imported. Nevertheless, the appearance of complete vessels in tombs and rarely settlements from important sites along the coast and slightly inland provides some idea of their distribution in this region of the Levant during the Middle and Late Bronze Age[119].

MBA Canaanite jars have been found at several major sites in coastal and inland Syria, as well as Lebanon (Fig. 3.37). A MBA Canaanite jar with painted decoration on the shoulder was excavated in a late MBA or early LBA context at Ras Shamra (Schaeffer 1949: 186-187; Courtois & Courtois 1978: 216-217). The local handled storage jars at Tell ʿArqa are of the Canaanite type (Thalmann 2002: 374-375, Fig. 9). MBA Canaanite jars were found in the Royal Tombs at Byblos (Montet 1929: 199-200, Plates CXVI and CXVIII; Tufnell 1969: 15-16, 25-26, Fig. 6) and from the excavations in the temples and settlement (Dunand 1954: 165, 198, Fig. 205, 1958: 593-592, Fig. 689). A complete MBA Canaanite jar and several rim fragments were found in the early MBA settlement layers at Beirut, while another complete vessel was found in a well (Badre 1997: Figs. 9, 21). Two jars were found in a rock-cut tomb also at Beirut (Saidah 1993-1994: 150-152). At least two MBA Canaanite jars were found in tombs at Ruweisé in Lebanon (Guigues 1938: 61, 73, Figs. 20 and 36a). A MBA Canaanite jar used for a child burial was found at Sidon, while another MB II (MB IIB) jar was included as a grave good (Doumet-Serhal 2004a: 108, 116, 118, 148, Figs. 50 and 53). Further south, a few graves at Tyre contained Canaanite jars that date either to MB IIB

[118] In the publications of material from the Levant the jars are referred to as storage jars, however, as the vessels in this discussion are of identifiable "Canaanite jar" type, this term will be used.
[119] As distinguishing between "Canaanite jars" and handleless storage jars is difficult from rims, this section will only discuss complete examples.

or LB I (Bikai 1978: 64-65, Plate LIIA)[120]. Canaanite jars were found at Hazor dating from the MBA (Ben-Tor 1989: 305, Plate CCXCVI; Ben-Tor *et al*. 1997: 34-35, 196-197).

Fig. 3.37: Distribution of Canaanite jars in the Levant during the MBA (University of Chicago base map)




Several large sites along the coastal plain of Palestine have produced MBA Canaanite jars. At Tel Kabri, some MBA Canaanite jars were found in a tomb (Kempinski 2002: 115-116, Figs. 5.28). A room at Tel Nami contained a number of MB IIA Canaanite jars (Marcus 1995: 596, Fig. 1). Megiddo produced a number of complete examples from Strata XII, XIII, XI, X, and IX (Loud 1948: 5, 87-92, Plates 16, 18, 27, 35, 42, 51, 52, 117, 118, and 128)[121]. The excavations at Tel Aphek (Ras el-ʿAin) revealed a stratified sequence of MB IIA Canaanite jars (Beck 1975, 1985). Canaanite jars dating from MB II (MB IIB) to MB III (MB IIC) were found in settlement contexts at Shiloh (Bunimovitz & Finkelstein 1993: 91, 100-101, 103-104, 106, 115-117, 120-121, 123). A group of tombs excavated near the harbour at Tel Aviv contained MBA Canaanite jars, typically two per internment (Kaplan

[120] Sites with published storage jar rims, some that are likely to be from Canaanite jars, includes Tell ʻAtchana/Alalakh (Heinz 1992), Ebla (Matthaie 1980), Tell Mishrifeh/Qatna (Iamoni 2008), Tell Nebi Mend/Qadesh (Bourke 1993), Kamid el-Loz/Kumidi (Hachmann 1980), and Pella (McNicoll *et al*. 1992).
[121] Fragmentary rims were also found at Megiddo (Finkelstein *et al.* 2000: 199-201, Fig. 9.7).

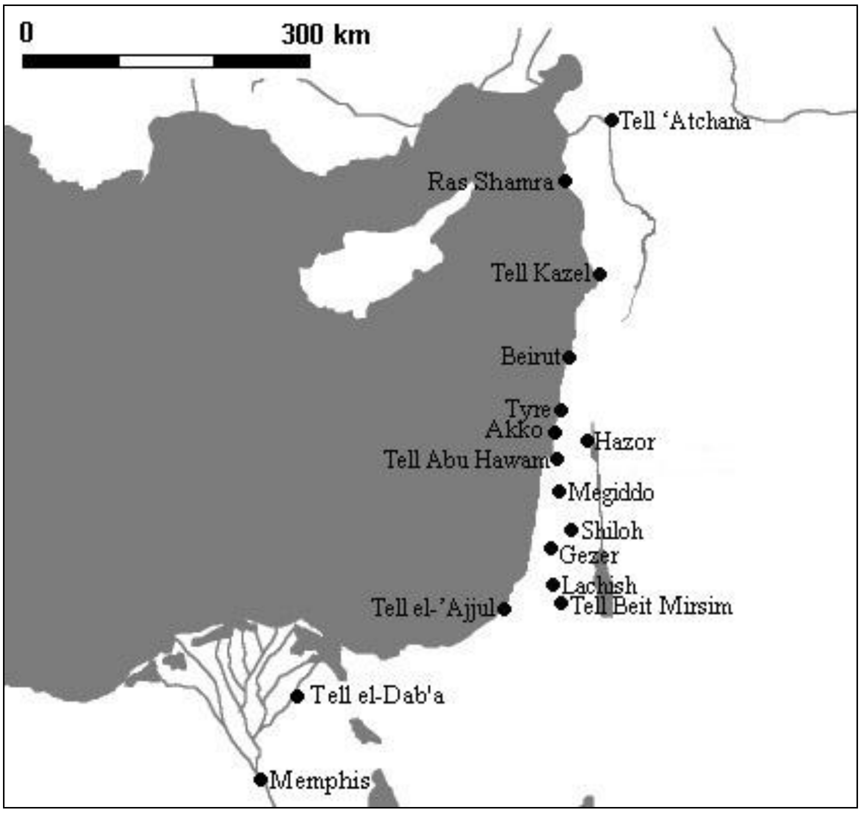
1955: 1-4, 8, Fig. 1 and Plate II). At least one tomb from Gezer contained a MBA Canaanite jar (Macalister 1912: Plate LXI), while two nearly complete vessels were more recently excavated (Dever *et al.* 1970: Plate 30). The site of Ashkelon contained many rims identified as Canaanite jars within the Moat Deposit dated to the MB IIA (Stager 2002: 353-355). Canaanite jars were discovered in several tombs at Lachish/Tell ed-Duweir (Tufnell 1958: 220-224, Plate 8), while renewed work at the site revealed a sequence of jars in settlement layers (Singer-Avitz 2004: 904, 914, 918). MBA Canaanite jars were found in the recently excavated tombs at Tell Beit Mirsim (Ben-Arieh 2004: 12, 14, 16, 29). Jars were recovered from the tombs in the Courtyard Cemetery at Tell el-ʻAjjul and from the burials in Cave 303 (Tufnell 1962: 9-35, 1980: 37, 42). Petrie (1931: Plate XLVI, 1932: Plate XXXII, 1933: Plate XXXVII, 1934: Plates LII-LIII, Petrie *et al.* 1952: Plates XXVII) also found several MBA Canaanite jars within the settlement, and from other tombs.

Most of these sites in the Levant also had Canaanite jars dated to the LBA, illustrating continuity in production and trade (Fig. 3.38). A storage room at the port of Ugarit, Minet el-Beida, was filled with LBA Canaanite jars providing a clear indicator of their importance in Eastern Mediterranean trade (Fig. 3.27; Schaeffer 1932: 3-4, Plate III.3, 1939: 30, Plate IX). Additional complete examples were found in several tombs at both Minet el-Beida and Ras Shamra (Schaeffer 1949: 150-151, 184-185, 190-191). The excavations at Tell ʻAtchana/Alalakh produced several LBA Canaanite jars from the settlement in Level IV (Woolley 1955: 318-319, 326, 335, 387, 399, Plate CXVI). Excavation at Tell Kazel recovered Canaanite jars from the LB II levels (Badre & Gubel 1999-2000: 152, 166, 172, 174-175, Figs. 26 and 32). However, some of the vessels do not resemble the typical Canaanite type and may represent jars used at the site for storing goods; others appear similar to jars found on Cyprus (described below). Excavations at Tyre produced a fairly continuous sequence of LBA Canaanite jars (Bikai 1978: 43-46, 48, Plates XLIX and XIV). The site of Hazor produced several LBA Canaanite jars (Ben-Tor 1989: 237, 286, Plates CCLXVI and CCXC). LBA Canaanite jars were found in tombs excavated near Akko, with typically four jars found in each burial (Ben-Arieh & Edelstein 1977: 16-17, 22 Fig. 10)[122]. Nearby, tombs at Tell Abu Hawam also contained between two to three LBA Canaanite jars (Anati 1959: 96-97, 100 Fig. 7). At Megiddo, LBA Canaanite jars were found in Strata VIII and VII (Loud 1948: Plates 59 and 64). A few rims, specifically identified as Canaanite jars, were uncovered from LBA strata at Shiloh (Bunimovitz & Finkelstein 1993: 132, Fig. 6.37). From

[122] One jar is undoubtedly an import from Egypt based on its distinctive shape (Ben-Arieh & Edelstein 1977: 16-17, 22 Fig. 10.9).

Gezer, several tombs and caves contained LBA Canaanite jars (Macalister 1912: Plates XXVI, XXXIII, XXXVII, and LXXXIII) and some examples were found in the settlement (Dever *et al.* 1974: Plates 23-26, 28). A number of LBA Canaanite jars of various shapes were uncovered from the settlement and tombs at Lachish/Tell ed-Duweir (Yannai 2004: 1038, 1042, 1044, 1048, 1053; Tufnell 1958: 224, Plate 8). Tombs at Tell Beit Mirsim held nearly complete LBA Canaanite jars (Ben-Arieh 2004: 18-19, 27, 33). The excavation by Petrie (1932: Plate XXXIII) at Tell el-ʻAjjul also uncovered LBA examples[123].

Fig. 3.38: Distribution of Canaanite jars in the Levant during the LBA (University of Chicago base map)

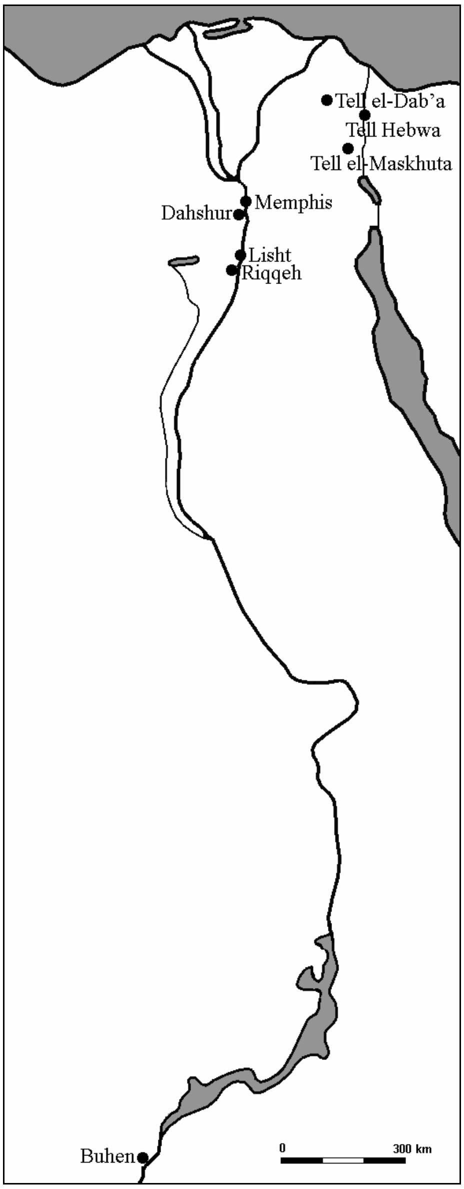



Within Egypt, the distribution of Canaanite jars varied by region and period (Fig. 3.39). Numerous MBA Canaanite jars were found at Tell el-Dab$^{c}$a from the earliest layers to the end of habitation (Bietak 1991b; Czerny 1999; Fuscaldo 2000; Aston 2002, 2004; Hein and Jánosi 2004; Müller 2008; Forstner-Müller 2008). At Tell el-Maskhuta, MBA Canaanite jars appeared throughout the six strata, dating to the Second Intermediate Period (Redmount 1995a: 185, 188, 1995b: 77, Fig. 7, 1993: 4, 14, Fig. 3). Some were also found at Tell Hebwa

[123] Sites with LBA rims of possible Canaanite jar type are Tell Mishrifeh/Qatna (Iamoni 2008), Beirut (Badre 1997), and Megiddo (Finkelstein *et al.* 2000).

(Abd el-Maqsoud 1998: 239-45). During a survey of the eastern Nile Delta, fragments of "Palestinian amphorae" were noted for sites with Second Intermediate Period remains (van den Brink *et. al* 1987: 14). Outside the Delta, however, MBA Canaanite jars are not as common, possibly due to their fragmentary state in settlements, which are poorly preserved and rarely excavated for this period. In addition to those at Memphis (Bourriau 1987: 11), two base fragments and a rim fragment from MB IIA Canaanite jars were found in the pyramid complex of Amenemhat III at Dahshur (Arnold 1982: 41-42). Settlement contexts of 13$^{th}$ Dynasty date at Lisht contained MBA Canaanite jar sherds (Arnold *et al*. 1993: 20-29). A possible intrusive MBA Canaanite jar was uncovered in an 18$^{th}$ to 19$^{th}$ Dynasty tomb at the heavily plundered cemetery of Riqqeh, although, it is possibly a very early 18$^{th}$ Dynasty example (Engelbach 1915: 10, 21, Plates XXXVII and XLIV). While, difficult to determine due to the poor publication image, a possible MBA jar was uncovered in the 12$^{th}$ Dynasty cemetery at Buhen (Randall-Maciver and Woolley 1911: 185-186, 195-196, Plate 94). If correct, this jar may have arrived at the site due to royal acquisition of imported goods which were then sent to this fort near the Second Cataract. Large numbers of Canaanite jar sherds were found during a survey of sites in the Sinai (Oren 1997: 279, Fig. 8.25).

Fig. 3.39: Distribution of MBA Canaanite jars in Egypt (University of Chicago base map)

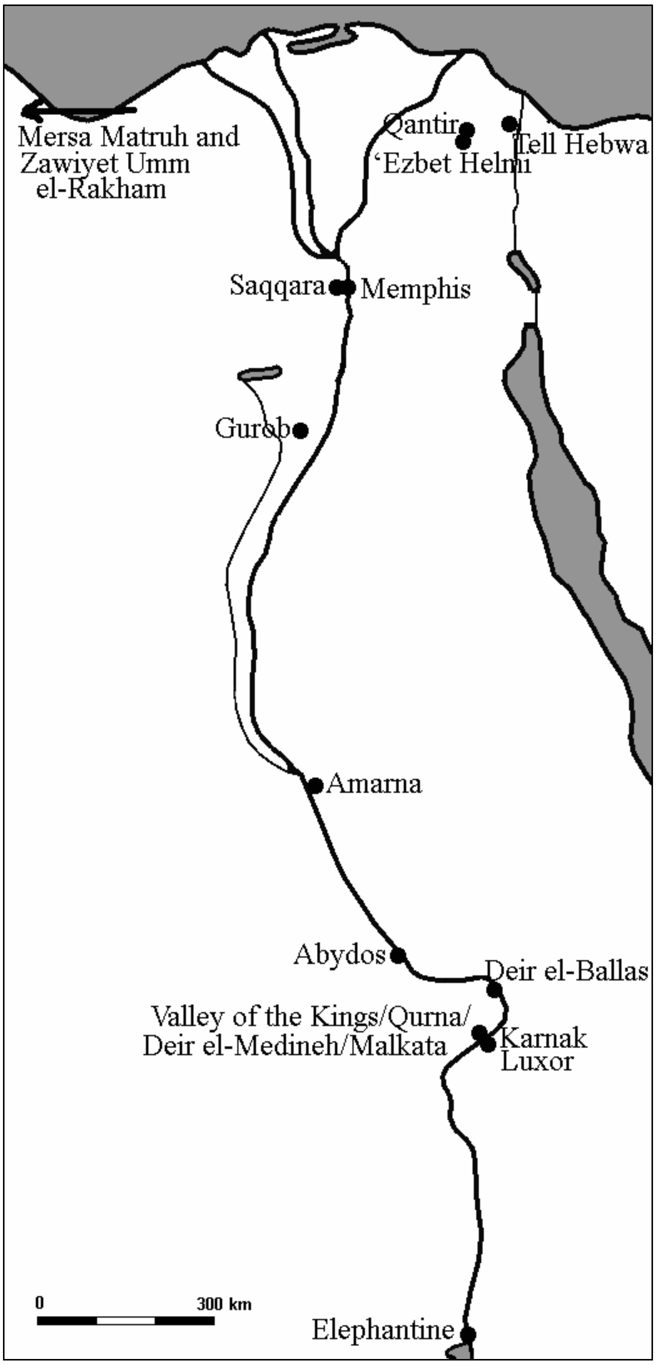



In the New Kingdom, examples of LBA Canaanite jars are known from many sites throughout Egypt (Fig. 3.40). LBA Canaanite jars were found in the Delta in 18th Dynasty tombs at Tell Hebwa IV (Aston 1996: 186, 196), 18th Dynasty levels at 'Ezbet Helmi (Aston 2004b: 176-178; Fuscaldo 2001: 158) and 19th to 20th Dynasty levels at Piramesses/Qantir (Aston 1998: 69-72, 627-677). Mastaba 3507 at Saqqara, dated to the early 18th Dynasty, had one Canaanite jar (Bourriau 1991c: 136-139, Fig. 6). LBA Canaanite jars were also found in elite tombs at Saqqara dating to the 19th Dynasty, such as that of Horemheb (Bourriau *et al.* 2005: 72-75), Tia and Tia (Aston 1997: 93-94, Plate 122), Iurudef (Aston 1991: 49, 53), Pay and Raia (Aston, B. 2005: 97-99, 117, 127), Ramose (Aston & Aston 2001: 52-53, 56, 60), and the tomb-chapels of Paser and Ra'ia (Bourriau & Aston 1985b: 40, 47, 49). The presence of LBA Canaanite jars at Memphis has already been mentioned (Bourriau 1990b). In Middle Egypt, jars were found in the late 18$^{th}$ to early 19$^{th}$ Dynasty settlement at Gurob (Petrie 1890: 32-34, Plate XX), and at Amarna, dated to the late 18$^{th}$ Dynasty (Rose 2007: 147-149, 292-294; Nicholson & Rose 1985: 139-140, 147-148). A probable LBA jar was found in the town of Aahmes I at Abydos, of early 18$^{th}$ Dynasty date (Petrie 1904: 37-38, 54, Plate LX), while more certain LBA Canaanite jars were recently excavated from the Ahmose Pyramid Complex (Budka 2006: 97-98, 100, 104, 115). Deir el-Ballas produced some fragments of LBA Canaanite jars (Bourriau 1990c: 22). Within Upper Egypt, LBA Canaanite jars were found at: Karnak North (Hein 2004), Luxor[124], the Valley of the Kings[125] (Aston *et al.* 1998: 142-144), Qurna (Seiler 1996: 225-8), Deir el-Medineh (Nagel 1938: 4, 24-25, 122), Malkata (Hope 1978: 75, 1989: 90), and Elephantine (Aston 1999: 7, 23, Plate 3).

LBA Canaanite jars were also found at sites along the "Ways of Horus", the road from Egypt to southern Palestine in the northern Sinai (Oren 1987: 83-84, 95, 103, 1993b:1389, 1391). Very few jars were recovered from 18$^{th}$ Dynasty sites, however, numerous examples were found in a 19$^{th}$ Dynasty fort. A rim of a jar was found at Serabit el-Khadim in the Sinai (Bourriau 1996b: 28-29). On the western side of the Delta, the New Kingdom site of Mersa Matruh/Bates's Island produced around twenty rim and base sherds of mostly LB IIB Canaanite jars (Hulin 2002a: 39-42; White 2003). Fifteen nearly complete examples of these jars were recovered from the Ramesside fort at Zawiyet Umm el-Rakham, to the west of Mersa Matruh (Snape 2000, 2003; Thomas 2003: 524-525; Snape & Wilson 2007: 58-60, 64-65).

[124] Personal observation by Aston (1997: 94, footnote 4).
[125] LB IIB jars in the tombs of Merenptah (Aston *et al.* 1998: 146), Ramesses IV (Aston *et al.* 1998: 158), Ramesses VI (Aston *et al.* 1998: 160), and Ramesses VII (Aston *et al.* 1998: 163).

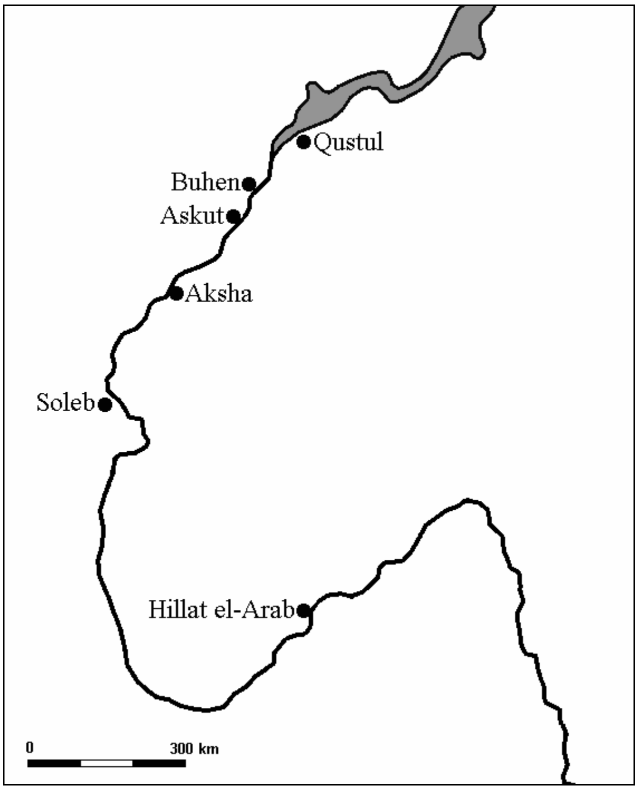
Fig. 3.40: Distribution of LBA Canaanite jars in Egypt (University of Chicago base map)




Sites within Nubia also contained LBA Canaanite jars (Fig. 3.41; Holthoer 1977: 97-99). Two jars from a tomb at Qustul are dated to the reign of Tuthmosis III (Williams 1992: 18, 43, 73, 87, 286-288). Many jars were found in the New Kingdom levels at Buhen (Serpico 1999; Maciver & Woolley 1911: Plates 38, 39, and 45; Emery *et al*. 1979: 161, Plate 60). A LB IIB example was recovered from House A at Askut (Smith 1995: 164, Fig. 6.15). A LBA Canaanite jar was found in a rock-cut tomb near Aksha, dating to the mid-18th

Dynasty (Vercoutter 1962: 115, plate XXXVII). A single tomb at Soleb, dated to the mid-18th Dynasty, held two LBA Canaanite jars (Giorgini 1971: 240, Plate XV). Four rock-cut tombs dating to the 19th Dynasty at Hillat el-Arab each contained two LBA Canaanite jars (Vincentelli 2006: 14-16, 77, 82, 125, 129, 139, 151). This site, three kilometres south of Jebel Barkal, is currently the farthest south that LBA Canaanite jars have been discovered. Unlike the more restricted MBA Canaanite jar distribution, the discovery of LBA Canaanite jars at so many sites along the length of the Nile Valley suggests that they were a common import and their contents had a broad distribution.

Fig. 3.41: Distribution of LBA Canaanite jars in Nubia (University of Chicago base map)




When the distribution of the LBA jars, whose provenance can be established based on the fabric classification developed by Bourriau(1990b) and the petrographic analysis by Smith (Smith *et al.* 2004), is examined, some interesting patterns can be noted (Table 3.5). P11 is the most common fabric, found at almost all sites and with a wide distribution from Qantir to Elephantine. Also probably manufactured in the Haifa Bay area, fabric P30 was found at many sites throughout Egypt. Fabrics P16 and P40 were the next most common, while fabrics P31 and P33, likely deriving from locations along the coast of northern

Palestine and Lebanon, were the rarest fabrics encountered. In sum, the production location(s) in the Haifa Bay area appear to have been the dominant exporters.

Table 3.5: LBA Canaanite jars found in Egypt by fabric and provenance (Smith *et al.* 2004), and sites

| Fabric | Provenance | Sites |
|---|---|---|
| P11 | Haifa Bay (Group 1) | Tell Hebwa IV, Qantir, Memphis, Saqqara (Tombs of Tia and Tia, Horemheb, Pay and Raia, Ramose, and tomb-chapels of Paser and Ra‘ia), Amarna, Karnak North, Malkata, Qurna, VofK*, Elephantine |
| P16 | Akkar Plain (Group 3) | Qantir, Memphis, Saqqara (Tomb of Horemheb), Deir el-Ballas, Amarna, Karnak North, Malkata?, VofK, Elephantine |
| P30 | Haifa Bay (Group 1) | Qantir, Memphis, Saqqara (Tombs of Iurudef?, Ramose and Pay and Raia), Amarna, Karnak North, Qurna, VofK, Buhen, Serabit el-Khadim |
| P31 | Northern Coastal Palestine (Group 2) | Tell Hebwa IV, Qantir, Memphis, Amarna, Karnak North |
| P33 | Coastal Lebanon (Group 5) | Qantir, Memphis, Karnak North, VofK |
| P40 | Syria and Cyprus (Groups 4 and 6) | Qantir, Ezbet Helmi, Memphis, Saqqara (Tombs of Tia and Tia, and Horemheb), Amarna, Karnak North, Luxor, VofK, Buhen |

*VofK=Valley of the Kings

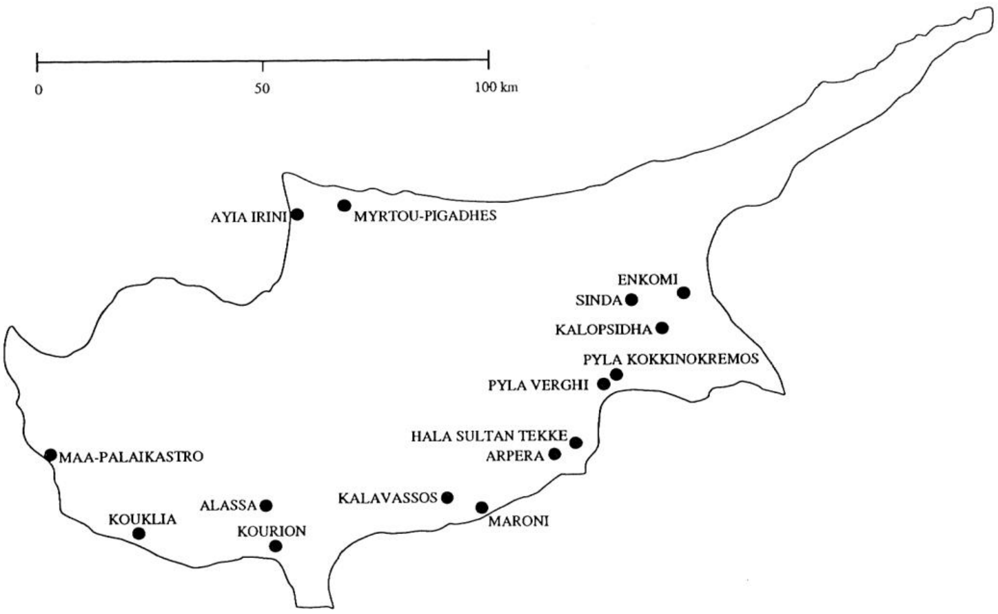
In terms of the appearance of fabrics at different sites, especially when the context is considered (i.e. settlement vs. funerary), the range of fabrics is typically greater in the settlements (with the exception of Karnak North) (Table 3.6). This suggests that the primary purpose of the contents of the jars was for utilization in daily life, with inclusion of the vessels in tombs as a secondary event. Chronologically, patterns are more difficult to discern, but the work of Aston (2004b) has examined the temporal variations in the presence of the different fabrics. The fabrics P31 and P33 appear early in the 18$^{th}$ Dynasty, but become less common in the later 18$^{th}$ Dynasty when the P11, P16, P30, and P40 fabrics become more prevalent. These fabrics continue to appear throughout the 19$^{th}$ Dynasty. Within most of Egypt, Canaanite jars dated to the 20$^{th}$ Dynasty are uncommon, reflecting the general reduction in importation of goods from the Levant possibly due to political instability at the end of the Late Bronze Age.

Table 3.6: New Kingdom Canaanite jars found in Egypt; site, date, context, and fabrics

| Site | Date/Context | Fabrics |
|---|---|---|
| Tell Hebwa IV | Mid-18th Dynasty (funerary) | P11, P31 |
| Qantir | 19th-20th Dynasty (settlement) | P11, P16, P23, P30, P31, P33, P40 |
| Ezbet Helmi | Early 18th Dynasty (settlement) | P40 |
| Tomb of Horemheb | Late 18th Dynasty (funerary) | P11, P16, P40 |
| Tomb of Tia and Tia | 19th Dynasty (funerary) | P11, P23, P40 |
| Tomb of Iurudef | 19th Dynasty (funerary) | P30, intact so not certain |
| Tomb of Pay and Raia | 19th Dynasty (funerary) | P11, P30 |
| Tomb of Ramose | New Kingdom (funerary) | P11, P30 |
| Tomb-chapels of Paser and Ra'ia | 19th Dynasty (funerary) | P11 |
| Memphis | New Kingdom (settlement) | P11, P16, P23, P30, P31, P33, P40 |
| Deir el-Ballas | Late SIP to early 18th Dynasty (settlement/funerary) | P16, P23 |
| Amarna | Late 18th Dynasty (settlement) | P11, P16, P23, P30, P31, P40 |
| Karnak North | New Kingdom (funerary) | P11, P16, P23, P30, P31, P33, P40 |
| Malkata | 18th Dynasty (settlement) | P11, P16? |
| Qurna | 19th Dynasty (funerary) | P11, P30 |
| Valley Kings | 19th – 20th Dynasties (funerary) | P11, P16, P30, P33, P40 |
| Elephantine | 19th Dynasty (settlement) | P11, P16 |
| Buhen | New Kingdom (settlement) | P30, P40 |

Areas in Cyprus also received Canaanite jars (Fig. 3.42). Late MBA to LB I Canaanite jars on Cyprus (Åkerström 1975; Crew pers. comm.) were found in tombs at Arpera-*Mosphilos* near Hala Sultan Tekke (MB IIC; Merrillees 1974: 45, 47, 54, 59), Kalavassos Village (LB I; Pearlman 1985: 168, 170-171), and Enkomi (LB I; Courtois 1981: 37-38). Hadjicosti (1988: 341) notes a lacuna in their appearance from Late Cypriot IB to Late Cypriot IIB (ca. 1300-1400 BC), while they are found from Late Cypriot IIC to Late Cypriot III (ca. 1300-1050 BC). During the latter period, examples come from Enkomi (Dikaios 1969: 248, 280, Plates 65, 77, 120, 125, and 297), Myrtou-*Pigadhes* (du Plat Taylor 1957: 53-55), Hala Sultan Tekke (Åström 1986, 1991a, 1991b) Alassa *Palita* (Hadjisavvas 1986: 67), and Kalavasos-*Ayios Dhimitrios* (South *et al.* 1989: 10, 134, 146, Fig. 29, Plate V; Heuck 1981: 66, 75, 77). LBA Canaanite jars from the site of Maa-*Palaeokastro* were examined macroscopically by Hadjicosti (1988: 340-363), who determined that some were imported, while others were likely local Cypriot productions. Various LBA Canaanite jars were discovered at Kition; several are probably imports, while others are specified as local examples (Karageorghis & Demas 1985: 57, 64, 73, 75, 227, 241). The unique shape of these possible local variants is reflected in a few nearly complete Canaanite jars found at Pyla-*Kokkinokremos* (Karageorghis & Demas 1984: 40-48, 51, Plates XXIII and XXXVIII) and one from Kalavasos-*Ayios Dhimitrios* (South *et al*. 1989: 107, Fig. 14). Except for one example, these vessels are also likely to be local productions due to their unusual form.

Fig. 3.42: Distribution of LBA Canaanite jars on Cyprus (Leonard 1995: Map 15.3, 248)




LBA Canaanite jars have also been found on Crete and in the Aegean (Fig. 3.43; Cline 1994: 95-97, 168- 179, Table 60). Many were found at Kommos, which was a large ancient port (Watrous 1992: 159-161, Figs. 71-72, Plate 53)[126]. Other LBA jars were uncovered at Pseira (Leonard 1995: 248), Kato Zakros in a Late Minoan context (French 1990: 73), as well as several fragments from Knossos and Khania (Leonard 1995: 248). Grace (1956) examined six jars from Mycenae, Menidi, Argos, and the Agora at Athens. These vessels were further discussed by Åkerström (1975), along with additional LBA Canaanite jars found at Argos, Asine, Menidi, Mycenae, and Pylos. These vessels were recovered from tombs, with the exception of several excavated at Mycenae. More recently, LBA Canaanite jars from settlement contexts were found at Akrotiri on the island of Thera (Marinatos 1976: 15, 30, Plate 69b), Koukaki in Attica (Leonard 1995: 243), and Tiryns

[126] See Kommos excavation reports by Shaw in *Hesperia* (e.g. 1981: 246-247, Plate 60; 1982: 166, 170, 193; 1986: 224, 261, 268-269).

(Kilian 1988a: 121, 128-129). A LBA Canaanite jar was discovered in a tomb near Boeotian Thebes, the furthest inland a vessel has been found (Symeonoglou 1985: 289).

Fig. 3.43: Distribution of LBA Canaanite jars in the Aegean (Leonard 1995: Map 15.2, 247)


Finally, LBA Canaanite jars discovered in several shipwrecks confirm their movement throughout the Eastern Mediterranean. The Cape Gelidonya wreck off the coast of Turkey, dated to ca. 1200 BC, produced mostly sherds (Hennessy & Plat Taylor 1967: Fig. 132, Nos. 2 and 3; Bass 1973: 34). However, the few nearly complete vessels appear more similar to the locally produced Cypriot jars discussed above. The Uluburun/Kaş shipwreck, also discovered off the coast of Turkey, but dated to ca. 1300 BC, held 149 Canaanite jars in three different sizes (Bass 1986: 277-279; Pulak 1997: 240). These vessels contained nearly one ton of *Pistacia* spp. resin, providing firm evidence for the large-scale trade in resin from the areas along the northern coast of Palestine, where the jars probably originated, to localities in the Eastern Mediterranean.

## *3.4. Conclusions*

While many excavators and ceramists have studied Canaanite jars from several areas of the Eastern Mediterranean, and their utilization for transporting commodities is fairly certain, these vessels still represent an enigma in terms of the areas specifically producing them. Their form and distribution argue for a primary place of manufacture in the Levant; supported by the types of commodities they carried that are produced in this region. The few studies of their raw materials confirm this impression and have begun to reveal those areas involved in their manufacture (Cohen-Weinberger & Goren 2004, Smith *et al*. 2004). The scientific analyses of excavated sherds from Kom Rabi'a can provide further clarification of the localities producing Canaanite jars during the MBA.

# Chapter 4: Samples and Methodology

## *4.1. Introduction*

In order to investigate the relationship between trade and politics during the Middle Bronze Age, samples of vessels known to have been utilized to transport goods from the Levant to Egypt were acquired. These Canaanite jar sherds derived from the excavations at Kom Rabi'a discussed in the previous chapter. To identify their location of manufacture, two scientific techniques well-established in the field for providing information on provenance were utilized: thin section petrography and chemical compositional analysis. The former technique suggested provenance locations based on the examination of geological maps showing where the minerals and clay used to produce the pottery were distributed. The latter data were generated through Inductively Coupled (ICP) Spectrometry to complement existing Neutron Activation Analysis (NAA) data. Several statistical tests were employed to identify patterns in the compositional data.

## *4.2. Kom Rabi'a Samples*

The sampling of the pottery from the Kom Rabi'a excavations was discussed in Chapter 3 (Bourriau 1991b). Once the random and purposive samples had been taken, the information recorded for each sherd included context, type of sample, sherd number, fabric, surface treatment, decoration, part, technology of manufacture, degree of preservation, drawing number (if drawn or typed to an already drawn example), shape class, and comments (Bourriau 1991b: 267; Gallorini & Bourriau in press). The fabrics of the samples were classified based on work previously carried out at Memphis that had established a type series. Each sherd was examined at 10x magnification with a hand lens or 25x magnification with a binocular microscope (stereoscope) to determine which fabric group it belonged. For each fabric group, the colour, texture, inclusions, sorting of the inclusions, hardness, and wall thickness were all recorded (see recording sheet in Appendix I, Fig. I.1).

The 1,565 MBA Canaanite jar sherds from the late Middle Kingdom and Second Intermediate Period contexts at Kom Rabi'a were all selected for recording due to their foreign fabrics. Once all the sherds had been classified into one of six fabric groups, labelled P100 to P105, 56 body sherds were chosen that represented each fabric group and encompassed any variability within the groups (Table 4.1). While most of the sherds derived from Level VIc and were of fabric P103, this is the result of selecting samples that encompassed the full range of foreign fabrics seen with the goal of determining all of the areas exporting Canaanite jars to Egypt (Table 4.2). The selected 56 sherds comprised 3.6% of the assemblage of the MBA Canaanite jars.

Table 4.1: List of Samples from Kom Rabi'a, including sherd number, fabric, context, level, and relative date of level

| Sample # | Sherd # | Fabric | Context | Level | Relative Date |
|---|---|---|---|---|---|
| Ownby 1 | 27178 | P105 | RAT 1318 | VIc | Mid-Late 13th Dyn. |
| Ownby 2 | 27773 | P105 | RAT 1584 | VIe | Mid 13th Dynasty |
| Ownby 3 | 27831 | P105 | RAT 1657 | VII | Mid 13th Dynasty |
| Ownby 4 | 24682 | P105 | RAT 1494 | VId | Mid-Late 13th Dyn. |
| Ownby 5 | 23741 | P101 | RAT 1412 | VIc | Mid-Late 13th Dyn. |
| Ownby 6 | 25054 | P101 | RAT 1462 | VId | Mid-Late 13th Dyn. |
| Ownby 7 | 27368 | P42 / P103 | RAT 1402 | VIc | Mid-Late 13th Dyn. |
| Ownby 8 | 24178 | P101 | RAT 1459 | VId | Mid-Late 13th Dyn. |
| Ownby 9 | 23594 | P102 | RAT 1429 | VId | Mid-Late 13th Dyn. |
| Ownby 10 | 27935 | P102 | RAT 1690 | VII | Mid 13th Dynasty |
| Ownby 11 | 25598 | P102 | RAT 1573 | VIe | Mid 13th Dynasty |
| Ownby 12 | 25434 | P102 | RAT 1552 | VII | Mid 13th Dynasty |
| Ownby 13 | 27139 | P101 | RAT 1264 | VIc | Mid-Late 13th Dyn. |
| Ownby 14 | 25243 | P101 | RAT 1479 | VId | Mid-Late 13th Dyn. |
| Ownby 15 | 27745 | P42 / P104 | RAT 1674 | VII | Mid 13th Dynasty |
| Ownby 16 | 4098 | P42 / P103 | RAT 951 | VIb | Mid-Late 13th Dyn. |
| Ownby 17 | 4364 | P42 / P103 | RAT 1172 | VIc | Mid-Late 13th Dyn. |
| Ownby 18 | 21290 | P101 | RAT 1545 | VIc | Mid-Late 13th Dyn. |
| Ownby 19 | 27080 | P42 / P103 | RAT 1296 | VIc | Mid-Late 13th Dyn. |
| Ownby 20 | 27788 | P104 | RAT 1584 | VIe | Mid 13th Dynasty |
| Ownby 21 | 21119 | P104 | RAT 1688 | VII | Mid 13th Dynasty |
| Ownby 22 | 60207 | P104 | RAT 1659 | VII | Mid 13th Dynasty |
| Ownby 23 | 21277 | P104 | RAT 1545 | VIc | Mid-Late 13th Dyn. |
| Ownby 24 | 20830 | P104 | RAT 1642 | VIe | Mid 13th Dynasty |
| Ownby 25 | 27317 | P34 / P105 | RAT 1190 (SMA) | III | Residual in New Kingdom |
| Ownby 26 | 10094 | P34 / P103 | RAT 740 | V | SIP/Early 18th Dyn. |
| Ownby 27 | 10407 | P34 / P103 | RAT 749 | V | SIP/Early 18th Dyn. |
| Ownby 28 | 4075 | P103 | RAT 912 | VIa | Mid-Late 13th Dyn. |
| Ownby 29 | 4342 | P42 / P103 | RAT 1078 | VIc | Mid-Late 13th Dyn. |
| Ownby 30 | 4099 | P42 / P103 | RAT 931 | VIb | Mid-Late 13th Dyn. |
| Ownby 31 | 4359 | P34 / P103 | RAT 1159 | VIc | Mid-Late 13th Dyn. |
| Ownby 32 | 4344 | P103 | RAT 1135 | VIc | Mid-Late 13th Dyn. |
| Ownby 33 | 4064 | P34 / P103 | RAT 894 | VIa-b | Mid-Late 13th Dyn. |
| Ownby 34 | 4336 | P103 | RAT 1071 | VIc | Mid-Late 13th Dyn. |
| Ownby 35 | 4079 | P103 | RAT 933 | VIa | Mid-Late 13th Dyn. |
| Ownby 36 | 4343 | P100 | RAT 1089 | VIc | Mid-Late 13th Dyn. |
| Ownby 37 | 4083 | P100 | RAT 933 | VIa | Mid-Late 13th Dyn. |

| Sample # | Sherd # | Fabric | Context | Level | Relative Date |
|---|---|---|---|---|---|
| Ownby 38 | 4051 | P103 | RAT 851 | VIa | Mid-Late 13th Dyn. |
| Ownby 39 | 4377 | P101 | RAT 1219 | VIc | Mid-Late 13th Dyn. |
| Ownby 40 | 4337 | P103 | RAT 1072 | VIc | Mid-Late 13th Dyn. |
| Ownby 41 | 4360 | P100 | RAT 1159 | VIc | Mid-Late 13th Dyn. |
| Ownby 42 | 4090 | P100 | RAT 934 | VIb | Mid-Late 13th Dyn. |
| Ownby 43 | 4209 | P100 | RAT 1067 | VIc | Mid-Late 13th Dyn. |
| Ownby 44 | 4066 | P103 | RAT 904 | VIa-b | Mid-Late 13th Dyn. |
| Ownby 45 | 4112 | P104 | RAT 992 | VId | Mid-Late 13th Dyn. |
| Ownby 46 | 10095 | P103 | RAT 740 | V | SIP/Early 18th Dyn. |
| Ownby 47 | 4346 | P34 / P105 | RAT 1155 (SMA) | III | Residual in New Kingdom |
| Ownby 48 | 4376 | P103 | RAT 1219 | VIc | Mid-Late 13th Dyn. |
| Ownby 49 | 4097 | P103 | RAT 957 | VIb | Mid-Late 13th Dyn. |
| Ownby 50 | 4114 | P34 / P104 | RAT 992 | VId | Mid-Late 13th Dyn. |
| Ownby 51 | 4402 | P42 / P103 | RAT 1145 | VIb | Mid-Late 13th Dyn. |
| Ownby 52 | 4403 | P42 / P103 | RAT 1159 | VIc | Mid-Late 13th Dyn. |
| Ownby 53 | 4214 | P42 / P103 | RAT 1067 | VIc | Mid-Late 13th Dyn. |
| Ownby 54 | 4404 | P42 / P103 | RAT 1189 | VIc | Mid-Late 13th Dyn. |
| Ownby 55 | 4351 | P34 / P103 | RAT 1139 | VIc | Mid-Late 13th Dyn. |
| Ownby 56 | 4367 | P34 / P100 | RAT 1139 | VIc | Mid-Late 13th Dyn. |

Table 4.2: Kom Rabi'a samples by level and fabric

| Level | P100 | P101 | P102 | P103 | P104 | P105 | TOTAL |
|---|---|---|---|---|---|---|---|
| III | | | | | | 2 | 2 |
| V | | | | 3 | | | 3 |
| VIa | 1 | | | 3 | | | 4 |
| VIa-b | | | | 2 | | | 2 |
| VIb | 1 | | | 4 | | | 5 |
| VIc | 4 | 4 | | 13 | 1 | 1 | 23 |
| VId | | 3 | 1 | | 2 | 1 | 7 |
| VIe | | | 1 | | 2 | 1 | 4 |
| VII | | | 2 | | 3 | 1 | 6 |
| TOTAL | 6 | 7 | 4 | 25 | 8 | 6 | 56 |

## *4.3. Macroscopic Examination*

The macroscopic examination of sherds establishes visual criteria for separating a large corpus of pottery into fabric groups. This classification is typically based on the surface treatment, colour of the sherd, hardness, and inclusion types, including their frequency, size, sorting, and shape (Orton *et al*. 1993: 135-140). Fabric distinctions result from differences in manufacturing processes, the utilization of various raw materials, and/or variability in production location. This last archaeological issue is the basis for provenance studies that seek to determine which fabric types were locally produced and which were imported. However, only a small selection of pottery can be examined with the expensive and time-consuming techniques of petrography and compositional analysis (Orton *et al*. 1993: 135). Thus, samples can be taken from each fabric group and the results can be related to the group as a whole (Peacock 1970: 376; Orton *et al*. 1993: 135). Once a fabric group has been established and the potential provenance for the material identified, further sherds can be categorized through binocular microscopy (Freestone 1995: 112).

The fabric classification for the Kom Rabi'a Canaanite jar material was established in the field by J. Bourriau (1991b) as described above. For the current study, a chip or fresh sherd break of each of the samples was taken for examination under a binocular microscope at 20x magnification[127]. The intention was to describe the macroscopic appearance of the sample and to re-classify 9 samples that were originally designated fabric P34, and 11 samples categorized as P42. The P34 and P42 fabric groups were established in the field based on residual MBA Canaanite jars found in the early Dynasty XVIII levels. Subsequently, when examples of MBA Canaanite jars were found in the late 13th Dynasty and Second Intermediate Period levels, a fabric classification for these jars was established utilizing the designations P100 to P105. Thus, those sherds previously identified as fabrics P34 and P42 had to be integrated into the P100-P105 system. The importance of the sherd descriptions was to enable the petrographic results to be related to the fabric groups. This would allow the sherds not sampled from each fabric group to be incorporated into the study through their fabric assignment. Thus, a more comprehensive study could be undertaken by utilizing information from all of the Kom Rabi'a MBA Canaanite jar material, and any patterns between fabric and vessel form could be related to the petrographically described provenance groups.

## *4.4. Petrographic Analysis of Ceramic Thin Sections*

### 4.4.1. Ceramic principles

Since the current study is primarily concerned with establishing where the MBA Canaanite jars from Memphis were manufactured, a method was needed that would provide the best possible means for answering this question. Within ceramic studies, the technique of petrography has long been acknowledged as the most direct method for establishing where a pottery vessel originated (Shepard 1956: 165-167). Petrography examines the clay and

[127] See Appendix I for details on the methodology employed.

minerals present in a ceramic that reflect the geology of the rocks from which these components derive[128]. Therefore, a link can be made between the location of the materials and the place where the vessel was produced. Based on ethnographic studies, 84% of potters travel less than 7 kilometres for raw materials, while 33% acquire them at a distance of less than 1 kilometre (Arnold 1985: 39-49). Thus, the geological origin of these resources is likely to be within the area of production[129]. For example, the most likely clay source used in a LBA pottery workshop at Lachish was located 200-300 meters away (Magrill & Middleton 2004: 2519). Depending on the variability of the geology within the study area, the identification of the locations of raw materials can give either a broad region or a more specific locale (Freestone 1995: 112-113; Whitbread 1995: 375-376; Tite 1999: 195-196). Petrographic examination also provides information on how clay(s) may have been modified; if materials were added; if force has been applied to form the vessel based on the orientation of voids and inclusions; and a general estimate of firing temperature due to clay and mineral changes (Peacock 1970: 379).

The petrographic analysis of archaeological ceramics is based on techniques borrowed from geology, mineralogy, and sedimentology (Rice 1987: 376). The technique allows for the identification of the raw materials for ceramic production. The clay type will reflect the geology of the area in which it was produced, either from weathered geological outcrops (primary) or deposits located at a distance from major rock sources due to erosional forces, such as water or wind (secondary) (Rice 1987: 36-37) [130]. Likewise, any sand or rock added to the clay (i.e. temper) will contain minerals indicative of its geological sources (Rice 1987: 118; Freestone 1995: 112). The inclusions in sand[131] derive from the geological outcrops that border a water source and contributed materials to it during periods of rainfall. The shape and size of the mineral inclusions provides additional information on its origin (Orton *et al*. 1993: 140-141). Geological and soil maps of the area of interest are examined to locate regions with the types of geology and clay sediments indentified in the thin section. Investigation of clay and mineral resources available in the area can reveal how they naturally

[128] The term petrology defines the study of rocks through their physical, chemical, and optical properties in order to understand their mineralogical composition and development (Vaughan 1995: 115).
[129] For certain clay types and slip materials this distance may be much greater, see the overview of ethnographic studies given by Rice (1987: 115-118). For utilitarian vessels such as Canaanite jars, the raw materials were probably acquired close to the location of production.
[130] The actual clay minerals are too small to be seen with a petrographic microscope.
[131] This term refers to mineral grains between 50 μm and 2 mm in diameter commonly present along rivers and on beaches.

relate to each other and how they may have been exploited by potters. Additionally, ceramic material from kilns can be examined for comparison.

### 4.4.2. Petrographic principles

Petrographic analysis of ceramics involves examining a thin slice (30 microns) of a sherd mounted on a slide with a microscope that allows the mineral inclusions and clay type to be identified. In this study, two thin sections were made of each sherd in order to acquire a more representative sample for analysis. The sections were taken from the sherd cross-section (see Appendix I for the methods to produce the thin sections).

The petrographic microscope, typically a binocular microscope, uses transmitted light and contains two polarizers (Gribble & Hall 1992: 1-3). The first polarizer is placed between the light source and the stage. It takes normal light which vibrates in all directions and filters it such that the light's electrical vector travels in only one plane, called plane polarized light. The plane polarized light is diffracted by the minerals in specific ways due to their unique crystal structure. The light, now out of phase, is recombined by the second polarizer located between the objectives and the oculars. This creates cross polarized light since the light is diffracted twice. Minerals can be examined under both plane and cross polarized light to determine their identity based on how they interact with both types of light.

A number of features seen in plane and cross polarized light allow the minerals to be identified. In plane polarized light, the mineral's colour and any changes in colour as the stage is rotated, called pleochroism, are diagnostic (Gribble & Hall 1992: 6-7). The shape or habit of the mineral and any cleavage are characteristic for certain classes of minerals (Gribble & Hall 1992: 7). Minerals will exhibit different relief, i.e. its ability to refract the light into the surrounding matrix (Gribble & Hall 1992: 7-9). Under cross polarized light, the mineral's colour, called birefringence, varies due to the wavelengths of light transmitted through the crystal structure (Gribble & Hall 1992: 10-11). The specific colours are identified on Newton's Scale. Additional diagnostic characteristics are the extinction angle (when the mineral goes black as the stage is rotated), twinning (based on planes within the mineral crystal structure), zoning (areas of different colour), interference figures (used to determine whether a mineral is uniaxial or biaxial), and whether the mineral is length slow or length fast using a sensitive tint plate (Gribble & Hall 1992: 11-14). All of these features contribute to identification as every class of minerals has a different structure and will show a unique set of characteristics based on this structure.

### 4.4.3. Petrographic studies

One of the earliest studies to employ petrography to examine ceramics was by Linné (1925, 1957) on South American pottery. More attention to the technique was taken after the excellent study by Shepard (1942, 1966) that examined the manufacture and distribution of Rio Grande Glaze-Paint ware. Shepard (1956: 156-168, 378-384) also discussed analysis of ceramic thin sections and methods for identifying temper. Within the U.K., the impetus for petrography in archaeology came from the soil sciences and the early studies by Hodges (1962) and Cornwall & Hodges (1964) who investigated ceramics from prehistoric Britain (Nicholson & Rose 1985: 140). Peacock (1970) outlined existing trends and proposed avenues for further study. A subsequent book of studies examining Roman and later ceramics within trade networks illustrated the applications of the technique (Peacock 1977).

More recently, focus has shifted to methodological issues as seen in Freestone, Johns, & Potter (1982), and Middleton & Freestone (1991), which also contains case studies. Further work on the methodology for describing and analyzing ceramic thin sections was developed by Whitbread (1989, 1995: 365-396) and applied to the study of Greek transport amphorae found throughout the Mediterranean. Whitbread adapted methods of description and analysis from both sedimentary petrology and the soil sciences to suit the unique demands of ceramic petrographers. The field continues to develop with the recently published volume (Quinn 2009) based on the Petrography of Archaeological Materials Conference at the University of Sheffield (attended by the author, Feb. 15$^{th}$ – 17$^{th}$, 2008).

### 4.4.4. Method of ceramic petrographic analysis

The selection of ceramic petrography to identify the likely provenance of MBA Canaanite jars from Memphis was based largely on the known success of this technique to answer such a research question and the utilization of this method for LBA Canaanite jars from Memphis (Bourriau *et al*. 2001; Smith *et al*. 2004). The geological variability of the area archaeologically likely to be the source region, the ready availability of published maps and information on the geology in this area, and the coarseness of the inclusions in the fabric all suggested this method would be informative (following Freestone 1995: 113-114). Additionally, the samples available for study were all body sherds from the same type of vessel[132]. Finally, sample selection was based on ensuring all fabric groups were represented,

[132] Because potters can use different clays for the various parts of a vessel, particularly between body and rim, sherds from the same area on a pot should be selected for analysis (Stienstra 1986: 32). Body sherds were also taken for petrographic analysis for the LBA Canaanite jar study (Bourriau pers. com.). For the study of the

as well as their range, in order that every area producing the Canaanite jars found at Memphis could be identified.

A standard procedure for the description of ceramic thin sections was developed by Whitbread (1995: 365-396). Most studies describe the minerals present and their size, shape, and sorting (Rice 1987: 379; Whitbread 1989; Orton *et al*. 1993: 140-141). For the current study, the protocol established by Bourriau & Nicholson (1992) and Bourriau *et al*. (2000) was followed for the description of the thin sections (see Appendix I for specific details). Mineral inclusions were identified along with their size and shape, their arrangement in the matrix[133], and the general character of the clay. This provided information on the methods of production that can be important for separating fabrics and for provenance distinctions (Whitbread 1995: 372). The thin sections were not analyzed in groups according to fabric, but were examined sequentially by sample number and then grouped based on similarities in clay and mineral inclusions.

The mineral inclusions identified were then utilized to locate potential areas of production based on the examination of geological maps of the modern countries of Israel, Lebanon, and Syria (Dubertret 1945, 1949, 1962; Dubertret & Weztel 1945; Wetzel 1945; Bartov 1994; Sneh *et al.* 1998a and b). Published reports on the geological features of outcrops and coastal sands in this region were also consulted. Identification of clay type was based on the work by Wieder & Adan-Bayewitz (2002), while regions where these soils existed were located on soil maps (Ilaiwi 1985; Dan *et al*. 1975).

Comparative material was consulted primarily at the Laboratory for Comparative Microarchaeology at the University of Tel Aviv under the guidance of Prof. Yuval Goren. Ceramics with a petrographically identified location of production were compared to the MBA Canaanite jar samples to suggest potential provenances. The comparison further assisted in clarifying the clay types. Thin sections from the LBA Canaanite jars from the Uluburun shipwreck (analyzed by Goren) were particularly helpful despite being later in date than the material currently under study. Similarly, the Amarna Letters, clay tablets from the Near East found in Egypt at the site of Amarna and dated to the LBA, provided information on available resources in an area through the petrographic analysis that was able to link to the location of the author of the letter and the constituents in the tablet (Goren *et al.*, 2004). However, this comparison was undertaken cautiously, as the tablets were often produced

material from Tell el-Dab^c^a (Cohen-Weinberger & Goren 2004), the location on the vessel from which the sample derived is not specified.

133 The term matrix refers to the fine-grained, typically clay, fraction in the thin section in which the inclusions are embedded (Whitbread 1995: 369).

from light coloured clays with few inclusions and were not highly fired. Nevertheless, these thin sections provided information on the characteristics of clay and mineral types in the region of production of the tablets. These various lines of indirect evidence were utilized to assign the petrographic groups an "interpreted" provenance, as ceramics from a kiln or resources collected from an area were not available to provide direct comparison.

### 4.4.5. Point counting ceramic thin sections

In addition to the thin section descriptions, quantitative data on the relative frequency of the individual mineral types was acquired through point counting (the methodology is described in Appendix I). These data assisted in grouping the samples based on common frequencies of inclusions. The technique involves using a stepping stage on the microscope to move the slide and count grains under the cross-hairs by their mineral type. Several aspects of this technique raise methodological questions: whether to count points, lines, ribbons, or areas, how many points to count, and how each grain is counted[134]. Middleton *et al*. (1985) found that traditional point counting and area counting provided the best data for statistical comparison. This study also suggested that 50 points was the minimum number to produce reliable data. Other studies have suggested that counting between 150 and 200 points is statistically appropriate for separating fabric groups (Streeten 1982: 128; Leese 1983: 49; Fieller & Nicholson 1991: 78, 88). For counting the grains, the multiple intercept approach is typically used so that when the cross-hairs land on the same inclusion twice, the grain is counted twice, therefore each point is counted towards either a mineral grain or the matrix. This method, as opposed to the single intercept (each grain counted only once) or nearest grain (counting the closest grain if the point is not on an inclusion), avoids bias and accounts for the size variation of the inclusions (Orton 2000: 186). For the current study, the method selected was multiple intercept point counting of 200 points per thin section to acquire data on the frequency of each mineral class within the various fabrics.

[134] Other methods for analyzing grain size, shape and frequency include utilizing a computer program to directly record and investigate the point count data (Whitbread 1991), coding the visually determined features and using statistical analysis to identify ceramic groups (Middleton *et al*. 1991), and image analysis (Streeten 1982; Fieller & Nicholson 1991; Whitbread 1991).

## *4.5. Chemical Compositional Analysis*

### 4.5.1. Ceramic compositional principles

While the petrographic analysis of the MBA Canaanite jars from Memphis was the primary method for establishing their provenance, compositional data were also important for exploring the relationship between the samples and confirming groupings. Additionally, these data would facilitate the comparison between the Memphite MBA and LBA Canaanite jars. However, the chemical data would not be able to provide information on the provenance of the material since there is no comparative reference database for pottery manufactured in the Levant. Therefore, the elemental data were acquired strictly to investigate compositional differences within the MBA Canaanite jar samples and the relationship between these samples and the LBA Canaanite jars.

The elemental differences found within pottery samples derive from the natural variation in the clays and temper employed to manufacture the vessels. This is because clay within a single bed will be more chemically similar than clay from different sources (Rice 1987: 413-414)[135]. This supposition is known as the 'provenance postulate' (Harbottle 1982: 67-77). Thus, pottery made from discrete clay source(s) and containing specific temper should be chemically different from pottery made with other materials (Wilson 1978: 219). The temper utilized, both in terms of mineralogy and proportion, will contribute to the elemental variability in pottery, even within samples made from the same clay (Buxeda i Garrigós *et al*. 2003). Thus, compositional data are based on the chemistry of the clay(s) and/or temper(s) employed and how the materials were manipulated (Bishop *et al*. 1982: 275; Day *et al*. 1999). Petrographic data are important for establishing if the compositional variability is due to either differences in clay, differences in temper, or both (Bishop *et al*. 1982: 319). Furthermore, petrographic information can be crucial to detecting similarities in technology that may either combine or separate chemical groups (Day *et al*. 1999: 1027). The mineralogical information can also establish if certain mineral types are likely to contribute significantly to the elemental data (Bishop *et al*. 1982: 295). Therefore, the petrographic data can ascertain if compositional groups reflect provenance differences, technological differences, or a combination of both.

[135] Alterations to the clay, addition of materials (i.e. temper, another clay, water), firing, the movement of elements post-depositionally, and contamination during sample preparation can all affect how chemically similar pottery samples are to each other (Rice 1987: 421-424; Orton *et al*. 1993: 146-147).

### 4.5.2. Petrography and compositional analysis

Despite these benefits, with the introduction of compositional analysis, many researchers have assumed this method alone would answer questions of provenance (Peacock 1977: 25; Wilson 1978: 227, 231). As a result, few studies have combined petrographic and chemical data. For coarse-grained pottery from geological heterogeneous areas, petrographic analysis serves as a rapid method for determining provenance (Peacock 1970: 381). However, if the pottery is particularly fine-grained and/or the local geology uniform, chemical analysis may be a better method for separating pottery into distinct groups (Bishop *et al*. 1982: 288; Freestone 1995: 112-113). However, problems arise in relating these groups to clay outcrops due to the alterations made during the process of pottery manufacture (Rice 1987: 419). These changes may make it impossible to provenance pottery based exclusively on compositional data. Overall, the utilization of petrography with its mineralological information and chemical analysis with its refinement, provide two complementary sources of data that increase the chances that the provenance of pottery will be correctly established (Peacock 1970: 381; Bishop *et al*. 1982: 297).

One of the earliest scientific techniques to analyze pottery was Neutron Activation Analysis (NAA) (Perlman & Asaro 1969)[136]. This technique increased in popularity due to its ability to acquire precise results on trace and rare earth elements (Harbottle 1970: 33). For provenance studies, NAA became the method most often utilized (see Hughes 1981 and Hughes *et al*. 1991 for several studies). This method is still important for certain areas of ceramic study, such as the Aegean, and continues in some sense to be the preferred technique for ceramic compositional data (Bishop *et al*. 1990: 539; Hein *et al*. 2002: 542). However, only a few studies have combined petrographic information with NAA data to examine ancient ceramics. The petrographic and NAA study by Goldberg *et al.* (1986) of Late Bronze Age Egyptian-style pottery from Deir el-Balah confirmed the importance of petrographic data as a cheaper, more effective method than NAA alone. The study of Early Minoan pottery by Day *et al.* (1999), gave pre-eminence to petrographic analysis, which was able to group the fabrics and reveal similarities in production technologies. This information was important for interpreting groups created from the statistical analysis of the NAA data. NAA and petrography were employed to examine Aegean pottery from Tell Kazel (Badre *et al*. 2005). Foreign-shaped vessels in an early dynastic tomb at Abydos, Egypt (Tomb U-j) were studied

[136] See Soete *et al*. (1972) for how NAA acquires compositional data.

through petrography, NAA, and XRF analyses (McGovern 2001; Pape 2001; Porat & Goren 2001).

Another chemical compositional technique that has been employed in ceramic studies is Inductively Coupled Plasma (ICP) Spectrometry. Data can be acquired by either optical emission spectrometry (OES) or atomic emission spectrometry (AES) for major elements and some minor elements, and by mass spectrometry (MS) for trace elements[137]. The Punic amphorae studied by Maniatis *et al*. (1984) were assigned a provenance based on petrography, while chemical analysis by ICP-OES confirmed the groupings. Additionally, this study utilized macroscopic examination to relate the results to the larger corpus of pottery (Maniatis *et al*. 1984: 207, 217, 220). Transport amphorae excavated from Locri Epizephiri (southern Italy) were studied by petrography and ICP-AES (Barra Bagnasco *et al*. 2001). Petrography and ICP-AES were also employed to examine Post-Classic (c. AD 850–1524) Mayan pottery in Guatemala (Cecil 2004). Pottery from several sites in north-western Sudan was analyzed by petrography, ICP-MS, and several other techniques (Klein *et al*. 2004).

Several studies have employed petrography, ICP and NAA[138]. The work by Gliozzo *et al*. (2005) revealed a good correlation between the petrographically created groups and those identified in the ICP-MS, ICP-OES, and NAA data. Porat *et al*. (1991) utilized petrography, NAA, and ICP-OES to examine EBA Egyptian pottery found in Canaan. The chemical data supported the distinctions made petrographically. Finally, the study by Tsolakidou & Kilikoglou (2002) employed not only NAA and ICP (OES and MS), but also X-ray fluorescence data. The petrographic information allowed for a better interpretation of the results from these techniques.

#### 4.5.3. Neutron activation analysis and inductively coupled spectrometry

For the current project, NAA data were available for some of the MBA and LBA Canaanite jars from Memphis (Al-Dayel 1995). However, research reactors have become increasingly unavailable, so that another technique had to be employed for acquiring compositional data from the remaining MBA samples. The great sensitivity (i.e. the lowest concentration level the instrument can detect) of NAA meant that a technique with equivalent sensitivity was needed for comparable data (Bishop *et al*. 1990: 538-539). A study by Tsolakidou & Kilikoglou (2002) compared several techniques for obtaining elemental data,

[137] See Thompson and Walsh (1989) and Jarvis *et al*. (1992) for how ICP acquires compositional data.
[138] For a unique combination of petrography and PIXE-PIGE (Proton Induced X-ray Emission-Proton Induced Gamma Ray Emission) see Petrie *et al*. 2007.

and concluded that ICP analysis provided data comparable to that from NAA. The study by Porat *et al*. (1991) utilizing NAA and ICP data showed that both techniques yielded similar elemental concentrations for some elements (i.e. As, Ba, Ce, Fe, and La), while dissimilarities existed for others (i.e. Ca, Co, Cr, Ni, and Yb). ICP-AES and NAA data employed by Ashton & Hughes (2005) were examined by principal components analysis (PCA), revealing similar results and confirming that the elements in common between the techniques contributed in a statistically similar way.

Comparison of ICP-MS and NAA data by Holmes *et al*. (1995) found that correlations between the data were better than 90%. However, problems arose in comparing the data from some elements, namely Cr, Hf, Rb, Sc, Th, U and Yb (Holmes *et al*. 1995: 348). The incomplete digestion procedure for the ICP data caused poor correlation between the Cr and Hf values, while fewer NAA counts were to blame for the comparability difficulties in the remaining elements. A similar study of the analysis of several standards by NAA, XRF, ICP-OES, and ICP-MS found that digestion procedures caused problems for the later technique, however, once mathematical correction procedures had been applied, the NAA and ICP-MS data produced comparable values (Hein *et al*. 2002). Finally, Al-Dayel (1995) found good agreement between the NAA and ICP-AES data for the elements Al, Ca, Co, Fe, Mn, Na, Sc, Ti, and V. However, for Cr and K the correlation was not satisfactory because both instruments had difficulties analyzing K, while the Cr bearing minerals were not completely dissolved during sample preparation for ICP (Al-Dayel 1995: 132-136, 156)[139].

### 4.5.4. Digestion of sample for ICP analysis

Several methods are employed to break down ceramic material for ICP analysis. The traditional procedure for digesting geological samples is to utilize an open vessel, typically a PTFE beaker, and hydrofluoric acid (HF) (Jarvis *et al*. 1992: 185). However, this method is usually insufficient to completely dissolve silica, the main constituent in pottery. To overcome this, pottery samples have been digested in closed PTFE beakers that allow pressure to increase the temperature (Jarvis *et al*. 1992: 192). Dissolution is more complete if the closed vessels are heated in a microwave, a method known as microwave digestion (Jarvis *et al*. 1992: 202; Holmes *et al*. 1995: 346). A comparison of this method for sample digestion with the traditional procedure, using an international pottery standard reference

[139] The digestion procedures for the ICP-OES data in Al-Dayel (1995) were not specified. They were likely to have been hydrofluoric acid digestion. The current study utilized lithium metaborate fusion that would have dissolved any Cr bearing minerals more completely (see below).

material, SARM 69, revealed that microwave digestion produced more accurate results (Papadopoulou *et al*. 2004). A final method utilizes alkali fusion (Jarvis *et al*. 1992: 196-201). This involves heating ceramic powder and lithium metaborate in crucibles to temperatures between 900°C and 1050°C to dissolve the ceramic material.

Bomgardner's (1981) comparison of digestion procedures for ceramic analysis suggested that alkali fusion produced the best results. This study employed a sample to lithium metaborate ratio of 1:4. Tsolakidou *et al*. (2002) compared the elemental data from pottery samples digested by open PTFE beakers, microwave digestion, and alkali fusion. This study evaluated the ICP data through comparison to NAA data from the same samples, which were taken as the "known" values. The results proved that lithium metaborate fusion produced the most complete dissolution and most accurate data. The study by Papadopoulou *et al*. (2004: 179-181) also suggested that the fusion procedure worked well on ceramic material, although microwave digestion produced better results. This last finding is in contradiction to the study by Tsolakidou *et al*. (2002). However, the ratio of lithium metaborate to sample can cause problems. If too little is used, the sample does not become fully dissolved; if too much, the high total dissolved solids (TDS) creates matrix effects (Tsolakidou & Kilikoglou 2002: 567; Tsolakidou *et al*. 2002: 185). The flux to sample powder ratio in the study by Tsolakidou *et al*. (2002: 185) was 2:1, while that used by Papadopoulou *et al*. (2004: 175) was 5:1. Thus, the latter study may have suffered from high TDS and matrix effects, which caused less accurate results for the samples prepared by alkali fusion than by microwave digestion. Matrix effects can be overcome to a degree by repeated dilution of the solution resulting from alkali fusion (Tsolakidou & Kilikoglou 2002: 567). However, dilution may reduce the concentration of trace elements so that they are below the detection limit of the instrument (Holmes *et al*. 1995: 346).

Overall, the advantages of lithium metaborate fusion are the complete digestion of samples, reduced matrix suppression effects, and few polyatomic interferences for trace elements. For the current study, as data comparable to NAA was required, it was crucial that the samples be completely dissolved to ensure the accurate determination of elemental concentrations. Thus, lithium metaborate fusion, with a ratio of 5:1 and considerable dilution to reduce matrix effects, was selected to digest the samples[140]. The sample preparation methodology followed as closely as possible that used for the Canaanite jar samples analyzed

[140] The procedures are outlined in Appendix I. Note: these procedures are not identical to those used by Tsolakidou *et al*. (2002) and Papadopoulou *et al*. (2004), but are based on those employed by the laboratory at University of London, Royal Holloway.

by NAA by Al-Dayel (1995: 63). Of the 56 MBA Canaanite jar samples, 22 had NAA data. Of these, six were selected to be analyzed also by ICP, while the 34 samples without NAA data were analyzed by ICP. All 56 samples had been sampled for petrography (see Appendix I for further details).

### 4.5.5. Elemental data

While most studies employing elemental data to examine ceramics must select the elements to assess, this was not the case for the current study[141]. The existing NAA data determined which elements needed to be measured by ICP analysis. However, the selected elements must be precisely and accurately determined by ICP, and not susceptible to post-depositional processes (Bishop *et al*. 1982: 295-296). The ICP-AES analysis produced elemental data for the major elements (expressed in weight%) calcium (Ca), aluminum (Al), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), phosphorus (P), silica (Si), and titanium (Ti), and the minor elements (expressed in parts per million, ppm) barium (Ba), chromium (Cr), nickel (Ni), strontium (Sr), vanadium (V), and zinc (Zn). ICP-MS data were acquired, expressed in ppm, for the following elements: cerium (Ce), cobalt (Co), chromium (Cr), cesium (Cs), dysprosium (Dy), europium (Eu), hafnium (Hf), lanthanum (La), lutetium (Lu), rubidium (Rb), scandium (Sc), samarium (Sm), tantalum (Ta), thorium (Th), uranium (U), and ytterbium (Yb).

## *4.6. Statistical Methodology*

### 4.6.1. Accuracy and precision

Before compositional data can be examined statistically, its accuracy and precision must be ascertained to determine whether its quality is sufficient for answering the archaeological question (Bishop *et al*. 1990: 539-540). For assessing accuracy, i.e. how similar the elemental measurement is to its “true” value, reference materials are analyzed at the same time as the samples. For this study, both internal laboratory standards with known values and the SARM 69 ceramic standard with internationally recognized values were employed. Precision relates to the consistency of the analyses of the same sample and to errors introduced during sample preparation and instrument operation. To assess the degree to which these errors may overwhelm the natural variability within the samples (variability

[141] For discussions of the issue of appropriate elements for ceramic compositional analysis see Harbottle (1970: 29), Wilson (1978: 221-222), Kuleff and Djingova (1996), and Hein *et al.* (1999).

that is crucial to the interpretations made) several samples are analyzed more than once. The degree to which the values for the repeat analyses vary gives an idea of the precision of the analyses. Typically, this variability should be less than 5% for the data to be acceptable. Depending on the goal of the study and the material analyzed, a precision level between 5% and 10% may be acceptable (Bishop *et al*. 1990: 540). For the MBA Canaanite jars, the same powder from three sherds was analyzed twice, and from five sherds, two samples were examined. This assessed both the precision of the technique and the heterogeneity of the ceramics and powder. The statistical methods utilized to assess the data's precision and accuracy are given in Appendix I, while the results are discussed in Chapter 5.

### 4.6.2. Data treatment

Studies have shown that most compositional data is logarithmically distributed (Bishop & Neff 1989: 63, 72; Baxter 2003: 75). By transforming the data into base 10 logarithms, the elemental data points that extend on both sides of the mean become evened out and made more symmetrical (Baxter 2001: 685-686). Particularly, if principal components analysis (PCA) is performed, the reduced variances will ensure that the first PCs are not overly influenced by the elements with the largest variances. In fact, most statistical tests (see below) assume a normal distribution, which can be achieved by transformation of the data to base 10 logarithms. Through this transformation, all of the variables are given equal weight in the statistical analyses, regardless of their absolute amount. For elements such as silica with large values in pottery compared with the trace elements, this transformation is essential. Finally, the data must be put on the same scale as the major elements are expressed as wt%, while the minor and trace elements are reported in ppm.

Due to these considerations, the MBA NAA and ICP data were transformed into base 10 logarithms. Examination of several different methods for preparing data for statistical analysis suggests that this is the best method for most cases (Bishop & Neff 1989: 63, 72; Baxter 2003: 75). Some studies of ceramic compositional data apply a dilution factor to reduce the affects of large quantities of quartz ($SiO_2$) and limestone ($CaCO_3$) temper (see Al-Dayel 1995; Bourriau *et al*. 2006). Particularly for studies relating ceramics to potential clay sources, the mathematical procedure attempts to remove the elemental contribution of "single element" temper so that only the clay compositional data remains (Mommsen *et al*. 1988; Beier & Mommsen 1994). As part of the author's MSc thesis, experimental ceramics were made with the same clay but tempered with lime or quartz sand (Ownby 2006). When the X-ray fluorescence data from the tempered and un-tempered samples was compared, the changes in the element data were not a straightforward dilution. This raises concerns about a mathematical procedure designed to remove from the elemental data presumably “clean” temper such as quartz sand and limestone. However, a recent re-evaluation of the utility of applying a dilution factor to compositional data seems to maintain its validity (Sterba *et al*. 2009). For the current study, the petrographic examination had suggested that the clays utilized to produce the MBA Canaanite jars were similar, and that differences in temper may relate to different locations of production. Thus, the elemental contribution from the temper was important to retain in the statistical analyses of the compositional data.

#### 4.6.3. Selection of elements for analysis

The compositional analysis of ceramics produces a large body of data for numerous elements. However, not all elemental data is useful for analysis. For example, certain elements, such as Br, Cl, and S, are affected by firing (Rye & Duerden 1982; Cogswell *et al*. 1996). Others are altered due to post-depositional processes, such as the leaching of Ca, K, and Na at sherd surfaces (Franklin & Vitali 1985; Schwedt *et al*. 2004). Trace elements tend to be more resistant to movement or alteration under burial conditions. The petrographic data from the MBA Canaanite jar sherds suggested that most were consistently fired below 850°C (lack of decomposed limestone). Thus, affects from varying firing temperatures should be minimal. The exterior surface of the samples was removed before chemical analysis to reduce any post-depositional affects (see Appendix I). Although, all the samples were subjected to similar post-depositional conditions since they derive from the same site. This also applies to the LBA Canaanite jar sherds from Memphis. The petrographic examination proved important for assessing whether firing or post-depositional processes were likely to introduce chemical variability.

For the analysis of the compositional data, elements with poor accuracy and precision (discussed above) may obscure significant variability (Baxter & Freestone 2006: 514). Omitting problematic elements can provide clearer results, but it should be done cautiously in case these elements are significant for discriminating between groups. For the current study, the statistical analyses were run initially with all of the data included as well as any sample outliers detected during the petrographic analysis. Second runs of the tests were performed omitting elements that had low accuracy and precision, or that had otherwise been identified as problematic (poorly correlated between the NAA and ICP data; see below). The second analyses also had the sample outliers removed. This procedure was consistently applied for the four statistical tests employed and for all of the data sets examined.

#### 4.6.4. Combining NAA and ICP data

Both NAA and ICP data were available for the MBA Canaanite jars. As ICP will analyze some elements more successfully than NAA, and vice versa, a mathematical procedure was needed to reconcile the differences between the data from the two techniques. For most studies comparing NAA and ICP data, correlation equations are acquired by plotting the results for the individual elements, with the NAA results on one axis and the ICP results on the other (Porat *et al*. 1991: 144-145; Holmes *et al*. 1995: 348; Ashton & Hughes 2005: 99). The best-fit line that passes through the points produces a regression equation and a coefficient value (r or its squared value $r^2$) that indicates the degree of correlation between the two data sets (Shennan 1997: 139-142). If this number is close to +1 or -1, correlation is high, either positive or negative, and typically the points all lie very close to the line passing through them. By this means, both numerically and graphically, similarity between the data produced by NAA and ICP can be compared. Additionally, the equation of the line passing through the points can be used to provide the correlating concentration of elements from one data set to the other. This mathematical procedure allowed the NAA and ICP data from six of the MBA Canaanite jar samples to create equations that could then provide a calculation for adjusting all of the data to be closer to the NAA results (see Appendix I for method). These procedures were carried out before the data were transformed into base 10 logarithms and prior to the analysis of the data through statistical tests.

#### 4.6.5. Statistical tests

For most archaeological questions, the use of a single statistical test is not advisable, as the particular manner in which that test examines the data may not reveal the full spectrum of the relationships between the samples. Therefore, several tests are often necessary to investigate patterns within the data that are archaeologically significant (Baxter & Freestone 2006: 524). Further, as various statistical tests examine data in different ways, results from tests are rarely identical (Bishop *et al*. 1982: 307). However, running several tests ensures that data are thoroughly explored, assumptions are tested, and linkages between groups of samples confirmed. This principal was applied in the current study, with four different statistical tests consistently utilized to examine the NAA and ICP data: principal components analysis; hierarchical cluster analysis; K-means cluster analysis; and discriminant analysis[142]. The first three tests are exploratory in nature, i.e. no assumptions of patterns in the data are

[142] See Appendix I for how the tests were set-up for the analyses.

made, while discriminant analysis is utilized to test hypothesized relationships between the samples or groups in the data.

Principal components analysis (PCA) examines the variability within the elemental concentrations (Shennan 1997: 269-287; Baxter 2003: 73-83). By converting these concentrations into uncorrelated variables through linear transformations, not only can the greatest proportion of the variability be accounted for, but it can also be viewed two-dimensionally. Samples are plotted on the first two or three linear transformations, or principal components (PCs), placed at right angles to each other. Samples with similar variability are typically grouped together. The test will also identify the elements contributing variability for the first three or four principal components, allowing further tests using only these variables to be carried out. Finally, the cumulative variability accounted for by the components is calculated, with better results attained if fewer components account for more of the variability. This test was employed to reveal any groupings of the samples and to identify elements that were useful for revealing patterns in the compositional data.

Hierarchical cluster analysis (HCA) likewise does not make any *a priori* assumptions about the relationship of the samples. This agglomerative test groups the samples with the most similar compositions together and aims to define the most homogenous groups possible (Shennan 1997: 235-244; Baxter 2003: 92-99). It then connects through branches samples and groups that are gradually less and less similar until a dendrogram with all of the samples is generated. The degree of similarity is based on Ward's method, which examines the error sum of squares between the means of the existing clusters of samples. Groups are connected to similar groups by a short distance, while the connections to other compositionally different groups are shown by links at greater distances. For the NAA and ICP data, HCA was used to identify samples most similar to each other and to examine the resulting groupings. Additionally, this test can identify compositional outliers. The test also assessed the quality of the data by how close the two analyses from the same sherd were placed to each other.

Any patterns identified by the first two statistical tests, and the groups established through petrographic analysis, were tested by discriminant analysis (DA) (Shennan 1997: 350-352; Baxter 2003: 105-111). For this test, each sample is assigned to a group and the membership to that group is tested with the compositional data. However, unlike cluster analysis, DA focuses on the differences between the groups rather than their similarities by creating uncorrelated linear combinations. The elemental concentrations of the samples are plotted onto the first two linear combinations (i.e. functions), with each sample being plotted near the centroid whose composition is most similar to its own based on Mahalanobis distance[143]. The test then assesses the success of placing samples assigned to the same group together; however, samples at a distance will often be placed in a group even if they are dissimilar from the other samples in that group. The success is calculated as a percentage of the samples assigned correctly to their group. For the current study, DA was employed primarily to test the petrographic group assignments.

Finally, K-means cluster analysis (KCA) was run to account for correlating elements and confirm sample relationships (Shennan 1997: 250-251; Baxter 2001: 688). While the test is similar to HCA in focusing on compositional similarities between samples, unlike HCA, the test is reiterative and utilizes several starting samples. The technique begins with a certain number of different samples that become the centres for the resultant clusters. Additional samples are placed next to the cluster to which they are closest, based on Euclidean distances. Samples are subsequently moved until each cluster contains the maximum homogeneity between its group members, and the differences between the groups are the greatest. Once all the samples have been placed in a cluster, the data are examined again to ensure every sample is in its appropriate group. However, this test will cluster the data regardless of whether the groupings have any archaeological meaning. As KCA requires that the number of clusters created be specified, it was best run after the HCA and DA had suggested the number of groups in the data.

#### 4.6.6. Statistical methods for point count data

The raw point count data from the MBA Canaanite jars were transformed into percentages for each category of inclusions to provide a relative frequency for the constituents. This enabled a comparison of the amounts of each inclusion in the sample and between samples. The percentage of clay matrix was also important for distinguishing between samples. Histograms were made for each sample showing the percentage of matrix, quartz, limestone, and chert. The samples assigned to a petrographic group were plotted on a single chart for comparison. While point count data was available from the LBA Canaanite jars, it was not used to compare the two groups of jars for several reasons. These data had been acquired in a slightly different manner and with more categories of inclusions. Further, differences between the jar samples included not just the frequency of inclusions, but also significant differences in inclusion size. Overall, the differences in clay matrix and

[143] This distance measurement means that, unlike the PCA and HCA, DA accounts for any elements that might be correlated. Several elements, such as Cr and Ni, are known to be naturally correlated and can affect the statistical analysis of ceramic compositional data.

inclusions between the MBA and LBA Canaanite jars was better assessed holistically through visual comparisons that could highlight the clay types, size and shapes of inclusions, relative amounts, and any other technological features.

## *4.6. Conclusions*

The 56 sherds selected for analysis in this study were based on the in-field fabric classification system that had identified six groups. As the goal of the research was to identifiy all of the various localities exporting commodities to Egypt in Canaanite jars, the chosen samples encompassed the full range of fabrics identified in the field. Petrographic analysis was then performed as this technique can link the clay and minerals utilized in producing the pottery to geographic regions of likely production. Compositional data, both ICP and NAA, were employed to further investigate the samples and confirm the groups identified in the petrographic analysis. For the statistical analysis, four test were applied consistently to the data sets to ensure a more rigorous investigation. In every case, each test was run once with all of the data and samples, and then again with problematic elements and sample outliers omitted. The results of the analysis of the MBA Canaanite jars is presented in the next chapter.

# Chapter 5: Results of Analyses of MBA Canaanite Jars

## 5.1 Introduction

The macroscopic, petrographic, and chemical analyses of the MBA Canaanite jar samples from Memphis aimed to establish their likely provenance, investigate any relationships between the samples, and relate this information to the fabric classification and rim forms. The integration of data from various scales ensured all of the available information was utilized to develop explanations. The interpreted provenances of the samples were established in order to assess from which regions the jars had been acquired in light of the political situation in Egypt and the Levant during the late MBA. Further, this provided the necessary data for comparison to the MBA Canaanite jars from Tell el-Dab$^{c}$a and the LBA Canaanite jars from Memphis.

## 5.2 Macroscopic Analysis Results

Laboratory macroscopic examination of chips taken from the 56 MBA Canaanite jar sherds was carried out to describe the individual fabrics and confirm the fabric classification made in the field. Additionally, some samples needed to be assigned a fabric number based on the P100-P105 system. The descriptions would assist in relating features seen petrographically to those viewed with a binocular microscope. More significantly, through macroscopic comparison, the results of the petrographic study of samples from the fabric groups could then be applied to the rest of the sherds in the fabric group that were not sampled. The macroscopic features of the samples in each fabric group are described below.

### 5.2.1 Macroscopic description of the fabric groups

For each sherd chip, the quantity and size of sand (quartz and other grains), limestone, and other minor inclusions (red-brown and black rock fragments, soft red-brown particles, shale fragments, gray inclusions, shell, and organic remains) were recorded[144]. Based on the petrographic analysis (see below) the red-brown rock fragments are probably iron oxides, the black rock particles are most likely manganese-titanium opaques, the soft red-brown particles are typically iron-rich clay pellets, and the gray inclusions are probably either fragments of chert or bioclasts, the calcified remains of oceanic species. Other fabric attributes recorded were sorting, porosity, hardness, wall thickness, and firing and surface colour. Typically,

[144] The fabric recording methods are given in Appendix I. The sample descriptions are in Appendix II.

samples within a fabric group shared the same features, although each group contained unusual samples and similarities between samples from different fabric groups was noted. The description of the samples in the fabric groups given below is based on the most common characteristics of a majority of the samples, although within each group there is variability in the inclusions, sorting, porosity, hardness, and colour. Table 5.1 lists the samples in each fabric group.

- P100 fabrics have common fine to medium-sized sand (Fig. 5.1). A few fine to medium-sized limestone and black rock fragments are present; rare plant remains are visible. Some samples also contain red-brown rock particles, soft red-brown inclusions, and shale. The sorting is generally good with medium porosity and hardness. The surfaces are typically reddish yellow (5YR6/6), while the break has a grey core (2.5Y5/1) and light brown (7.5YR6/4) to yellowish brown (10YR6/4) outer zones[145]. The wall thickness is between 7 and 8 mm.
- P101 fabrics are dominated by sand that is fine to medium-sized with some limestone fragments in sizes fine to medium (Fig. 5.2). Rare plant remains are present, while other inclusions comprise red-brown and black rock fragments, and grey-white particles. The constituents are fairly sorted and the porosity ranges from medium to dense. The medium hard fabric is reddish-yellow (5YR6/6 or 7.5YR7/6) on the surfaces and in the break, with some samples having a grey core (5YR5/1). The walls are between 7 and 8 mm in thickness.
- P102 fabrics exhibit mostly fine sand and fine to coarse-sized limestone inclusions, with some containing red-brown and black rock particles and no organic remains (Fig. 5.3). The sorting is fair and the porosity medium to dense, while the fabric is of medium hardness. The exterior surface colour is typically reddish yellow (5YR7/6), while the interior surface colour varies. The break has no zones, but is usually yellowish red (5YR5/8) to dark grey (5YR4/1). Wall thickness is typically 7 mm.
- P103 fabrics contain some fine to coarse-sized sand and limestone inclusions, with rare plant and shell fragments (Fig. 5.4). Additional inclusions comprise red and black rock particles, black basalt rock fragments, and shale and grey-white particles. The sorting is fair and the porosity is medium to dense, while the hardness is medium. The surface colour is reddish yellow (5YR6/6), although some are very pale brown (10YR7/4). The break can show a grey core (2.5Y5/1) with zones of light yellowish

[145] The number designations for the colour are based on the Munsell Soil Color Charts (1954). The zones refer to the different areas of colour seen in the cross section of a sherd.

brown (10YR6/4) to very pale brown (10YR7/4). The wall thickness ranges between 6 and 9 mm.

- P104 fabrics have some sand ranging in size from fine to coarse (Fig. 5.5). Fine to medium-sized limestone fragments are noticeable and there is a lack of organic inclusions. Other constituents are shale fragments, and red-brown and black rock particles. Sorting is fair, while the porosity and hardness are medium. The firing colour and break are usually red (2.5YR5/6) to reddish yellow (5YR6/6). Wall thickness is typically between 5 and 9 mm.
- P105 includes fabrics with fine to coarse sand and very common fine to coarse-sized limestone inclusions (Fig. 5.6). There are a few inclusions of red-brown and black rock fragments, while some samples have grey-white particles and microfossils. The constituents are fair to poorly sorted, while the porosity is typically medium. The hardness ranges from crumbly to medium. The surfaces and break are from brown (7.5YR5/2) to light red (2.5YR6/6) in colour, usually lacking a core. Wall thickness is between 5 to 9 mm.

Overall, this fabric classification progresses from those with prevalent, well sorted sand and few limestone inclusions to those with poorly sorted sand and ubiquitous limestone fragments. However, similarity among the P100, P101, and P102 groups is evident, probably due to the use of quartz-rich sand for tempering the clay. Likewise, P104 and P105 are analogous in containing large and common limestone pieces. The P103 group seems to cover fabrics in which neither sand nor limestone dominate, but large gray inclusions (bioclasts), shell, and rounded black basalt fragments are present in some samples.

Table 5.1: Summary of Fabric Groups

| Fabric Group | Samples* | Description |
|---|---|---|
| P100 | 36, 37, 41, 42, 43, 56 | common fine-medium sand, few fine-medium limestone, sorting good, medium porosity/hardness |
| P101 | 5, 6, 8, 13, 14, 18, 39 | very common fine-medium sand, some fine-medium limestone, sorting fair, medium to dense porosity, medium hardness |
| P102 | 9, 10, 11, 12 | common fine sand, some fine to coarse limestone, sorting fair, medium to dense porosity, medium hardness |
| P103 | 7, 16, 17, 19, 26, 27, 28, 29, 30, | some fine to coarse sand and limestone, |

| Fabric Group | Samples* | Description |
|---|---|---|
| | 31, 32, 33, 34, 35, 38, 40, 44, 46, 48, 49, 51, 52, 53, 54, 55 | sorting fair, medium to dense porosity, medium hardness |
| P104 | 15, 20, 21, 22, 23, 24, 45, 50 | some fine to coarse sand, common fine to medium limestone, sorting fair, medium porosity, medium hardness |
| P105 | 1, 2, 3, 4, 25, 47 | some fine to coarse sand, very common fine to coarse limestone, sorting poor, medium porosity, crumbly to medium hardness |

*All sample numbers preceded by "Ownby", see Table 4.1, page 100.

Fig. 5.1: Image of P100 fabric, Ownby 36, 10x magnification


Fig. 5.2: Image of P101 fabric, Ownby 18, 10x magnification

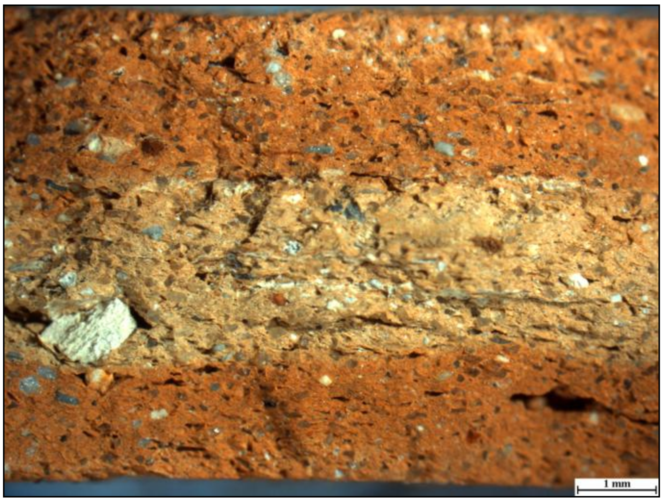
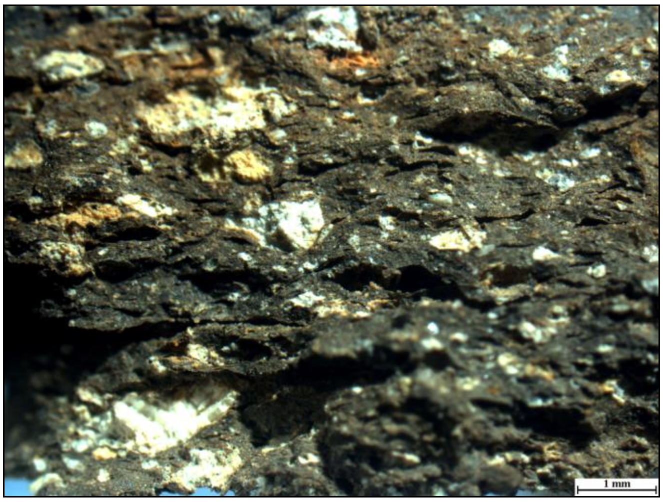


Fig. 5.3: Image of P102 fabric, Ownby 11, 10x magnification


Fig. 5.4: Image of P103 fabric, Ownby 17, 10x magnification


Fig. 5.5: Image of P104 fabric, Ownby 22, 10x magnification

Fig. 5.6: Image of P105 fabric, Ownby 47, 10x magnification




## *5.3 Petrographic Analysis Results*

The petrographic analysis of the 56 MBA Canaanite jar samples documented the type of clay, inclusions, sorting, percentage of inclusions within the matrix, grain size ranges (including the majority size range), optical activity, and colour of the sections in plane and cross polarized light. For the quartz/feldspar, limestone, and chert grains, their frequency, size and shape were also recorded, including the average shape and size. This information can assist in determining where the raw materials were acquired (i.e. along a river) and/or how they were processed. Based on the petrographic analysis, most samples could be placed into one of four major groups. However, some samples could not be assigned to a group, either because they were individual examples or they contained generalized inclusions that did not suggest a particular provenance, these have been labelled "outliers" (Table 5.2). The relationship between the four petrographic groups and the six fabric groups will be discussed at the end of the chapter.

Table 5.2: Interpreted Petrographic Groups

| Group | Samples* | Clay and Major Inclusions | Interpreted Provenance |
|---|---|---|---|
| 1 | 16, 17, 19, 30, 51, 52, 54 | Neogene marl clay; limestone, chert, chalcedony, geode quartz, hypocrystalline alkali olivine basalt | Akkar Plain |
| 2 | 4, 22, 24, 39, 45, 50 | Rendzina clay; limestone, chalk, chert, chalcedony, geode quartz | Inland Lebanon |
| 3 | 2, 3, 20, 21, 23, 26, 28, 29, 31, 32, 33, 34, 35, 40, 41, 42, 44, 49, 53, 55, 56 | Rendzina clay; bioclasts, limestone, chert, chalcedony, geode quartz | Coastal Lebanon |
| 4 | 1, 5, 6, 8, 9, 10, 11, 13, 14, 18, 36, 37, 43 | Rendzina clay, some with *Terra Rossa*; bioclasts, quartz, chert, limestone | N. Coastal Palestine |
| Outliers | 7, 12, 15, 25, 27, 38, 46, 47, 48 | Varied | Varied or General Inland Levant |

*All sample numbers preceded by "Ownby", see Table 4.1, page 100.

Provenances were postulated based on the location on geological and soil maps of the clay and mineral constituents in each group. The utilization of comparative ceramic material, such as the Amarna Letters, further supported the identification of potential locations of production. Sites with known MBA levels and located in the suggested geological area are given as possible locations of production throughout this thesis, however, the vessels could have been produced in the vicinity of those sites or at other sites in the region that have yet to be discovered. Nevertheless, it seems appropriate to suggest large sites as manufacturing locations since they are likely to have the resources and infrastructure to produce goods for exportation. Sites with ports are even more probable as production locations as the size of Canaanite jars indicates they were probably not transported great distances over land, while newly produced vessels at the port could easily have been filled and transferred to ships for export. Information on the technology of manufacture, such as the use of temper and firing temperatures, was also noted. For the descriptions given, the information includes the common constituents and their characteristics for a majority of the samples. However, within each group variability existed between the samples, as illustrated by the point count data. This is potentially due to a range of factors such as different potters/workshops, inconsistency in recipes, changes in materials utilized within the region, and chronological variation.

Fig. 5.7: Simplified Geological Map of Lebanon (from Dubertret 1970: Fig. 1) J= Jurassic, $C_{1\text{-}3}$= Lower Cretaceous (Aptian-Albian ), $C_{4\text{-}5}$= Upper Cretaceous (Cenomanian-Turonian), $C_6$-q= Senonian to Quaternary (including Eocene), B= Basaltic

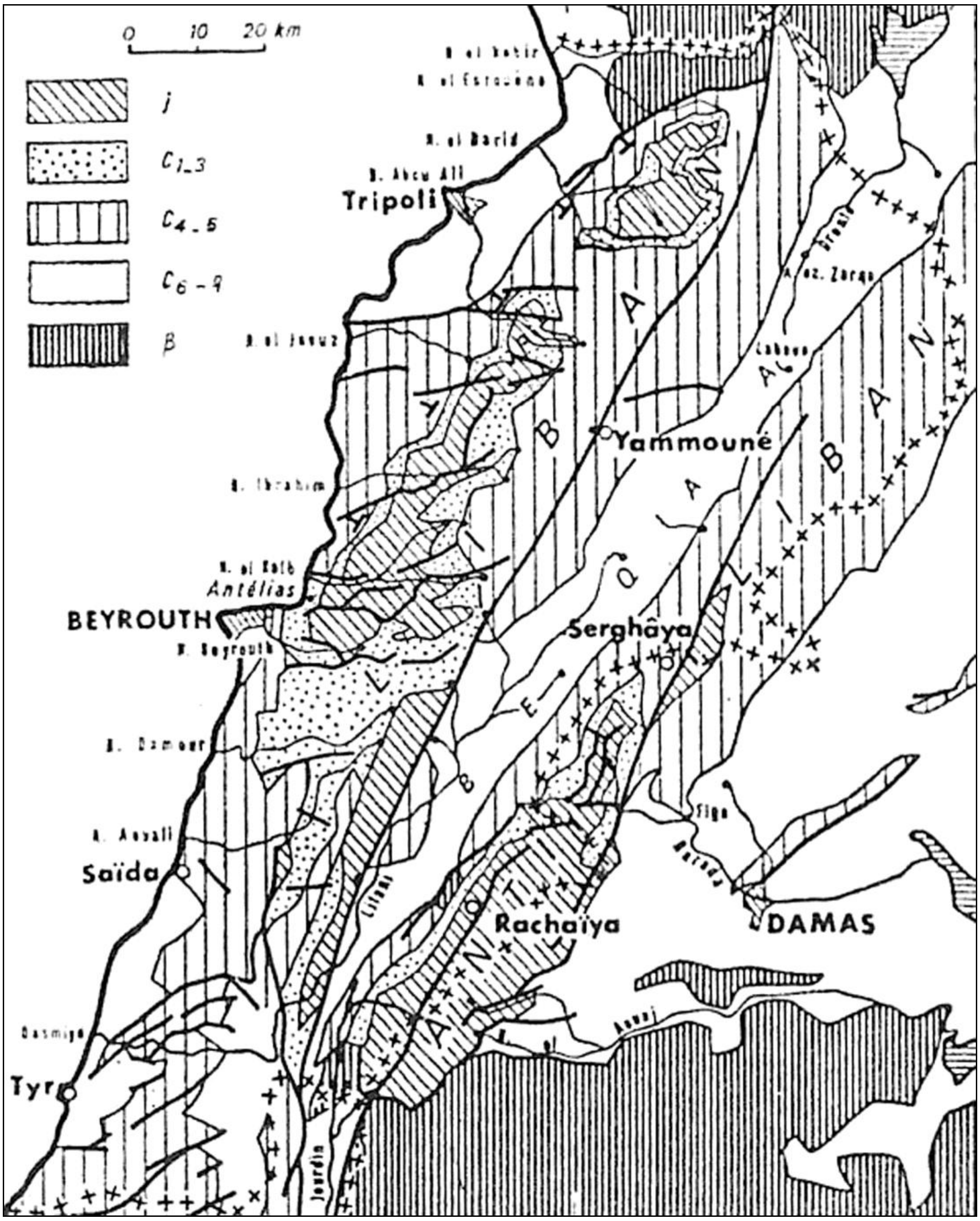


Fig. 5.8: Simplified Geological Map of modern Israel (based on Sneh *et al*. 1998a, b)

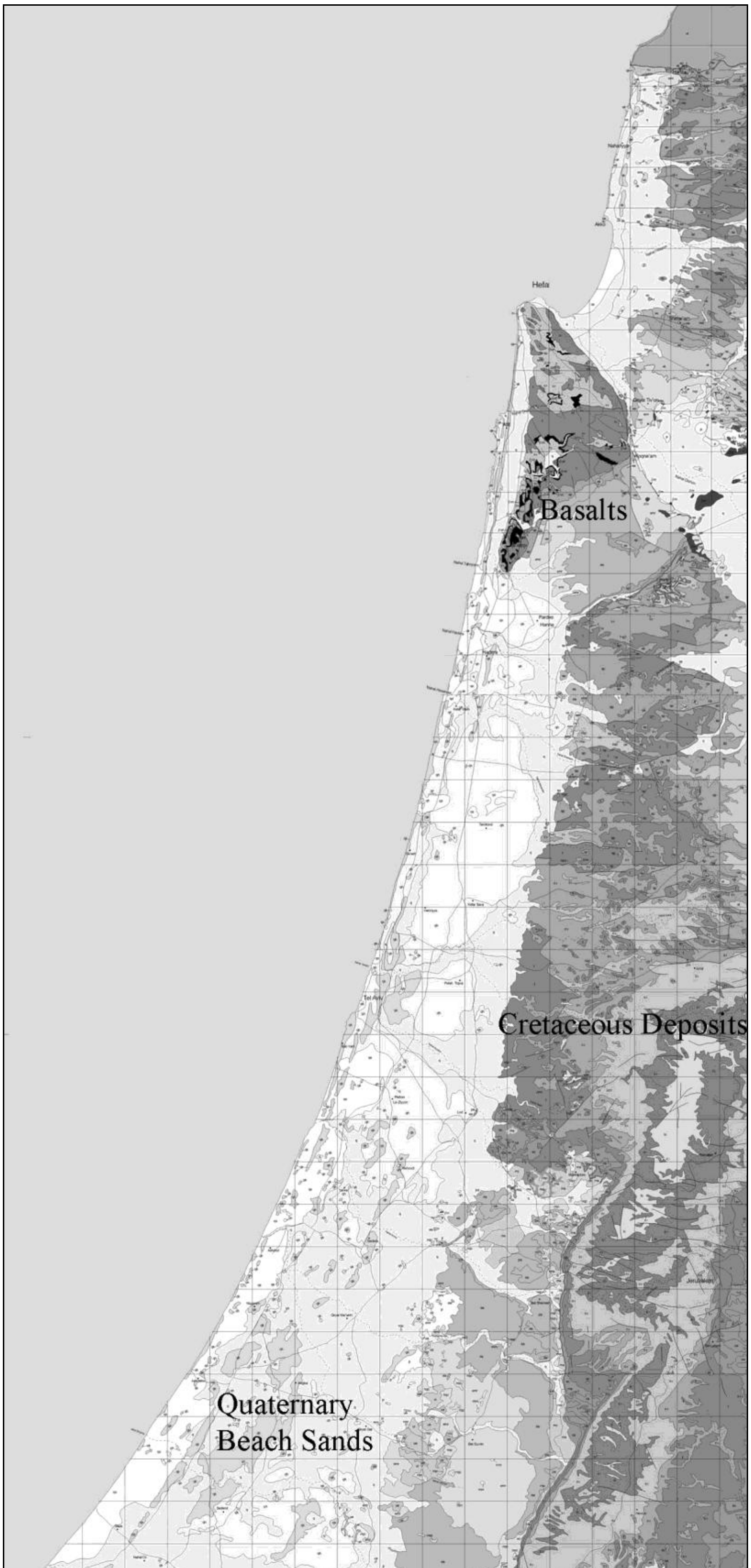
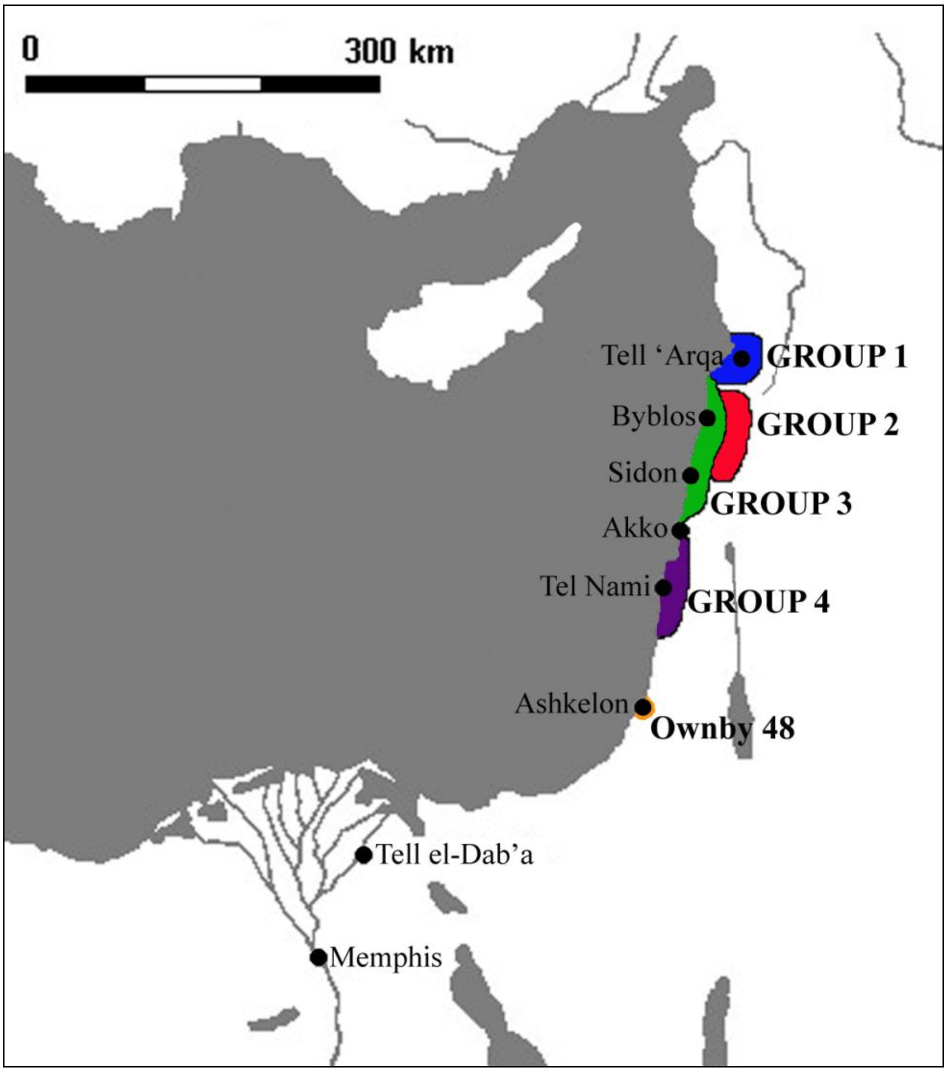


Fig. 5.9: Map showing interpreted provenance areas for Groups 1 through 4




### 5.3.1 Group 1 ("Akkar Plain")

#### *5.3.1.1 Clay, mineralogy, and technology*

The samples in Group 1 contain microfossils of *Bulimina*, *Globigerinoides*, *Globigerina*, and *Globorotalia* (Haynes 1981). These species were common during the Neogene and suggest that the clay derived from the weathering of a Neogene limestone outcrop. However, the reddish colour of the fabric, and the presence of red clay pellets, indicate that a *Terra Rossa*[146] clay was added to the Neogene marl. *Terra Rossa* is an iron-

[146] Technically, *Terra Rossa* is a soil; however, it contains clay and was utilized for pottery production. The same applies to the other clays mentioned in the text, which are classified as soils but include a high proportion of clay minerals enabling them to be employed for manufacturing ceramics.

rich clay found throughout the Levant (Wieder & Adan-Bayewitz 2002: 395-397)[147]. The dominant inclusions within the Group 1 samples are limestone, chert, geode quartz with inclusions (from metamorphic strain), chalcedony, and hypocrystalline alkali olivine basalt[148] showing various degrees of weathering (Fig. 5.10). The weathering process has devitrified some of the glassy phase, while some of the olivines and pyroxenes have become serpentinized. Less common inclusions are quartz, polycrystalline quartz, plagioclase, biotite, muscovite, iron oxides, opaques[149], clay pellets, pyroxenes, and serpentine. The plagioclase and pyroxenes in the matrix are typically derived from the basalt fragments. Some samples contain rare grains of K-feldspars, amphiboles, epidote, and tourmaline. The inclusions are poorly sorted, comprising anywhere from 5% to 30% of the matrix[150]. The typical size range is very fine to medium, although very coarse inclusions are almost always seen. The quartz/feldspar grains are sparsely present and vary in size from very fine to medium, with normally a subrounded shape. The limestone inclusions are mostly rounded, from very fine to very coarse in size, and frequent in the matrix. Chert fragments are of angular shape, both sparsely or rarely seen, and found in very fine to very coarse sizes. Most samples are slightly optically active under cross polarized light and from dark red to dark brown in colour, while they are usually medium red to medium brown in plane polarized light.

The optical activity and presence of intact limestone inclusions suggests the firing temperature was between 700°C and 800°C. Above 850°C, the limestone would begin to decompose and the clay particles would become sintered, resulting in an opaque phase that does not allow light to pass through, i.e. an optically inactive matrix. The quartz and limestone fragments are probably derived from the outcrop producing the marl clay, while the basalt inclusions are not natural to this sedimentary regime. However, their various weathering and rounded shape suggests a river system draining a location with basalt outcrops. This would create a mixed deposit along the river of basalts of slightly varying types and could include a secondary deposit of weathered marl clay. Thus, potters could have collected a calcareous clay with naturally existing fragments of limestone and basalt,

[147] The terminology is based on the Israeli Soil System and is used here in order to compare to the petrographic descriptions published for the Tell el-Dab$^{c}$a samples, see Chapter 6. *Terra Rossa* soil is classified as a Xerochrepts; see Ilaiwi (1985) for the distribution of this soil in Lebanon.

[148] Basalt consisting of glass with inclusions of plagioclase, olivine, and pyroxenes (Allaby & Allaby 2003: 273).

[149] Defined as black inclusions that do not allow light to pass through them, they are usually of titanium-manganese composition.

[150] See Appendix I for terminology.

likely deposited not far from the sources due to the size of the inclusions. Alternatively, the marl could have been acquired separately and sand dominated by basalt added as temper. The angular shape of the chert grains suggests that they may have been intentionally added, as they are not rounded due to river transport. In certain cases, *Terra Rossa* was also added to improve the workability of a highly calcareous clay.

#### *5.3.1.2 Interpreted provenance*

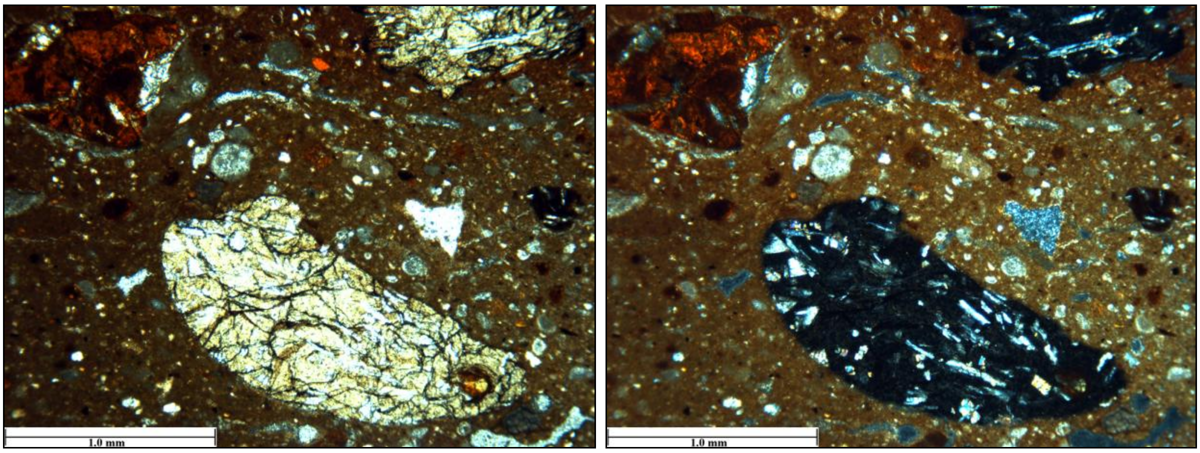
The Neogene microfossils in the clay and the alkali olivine basalt fragments are the best indicators for the potential provenance of these MBA Canaanite jars. Neogene deposits are found along the coast of Lebanon, particularly near Tripoli and in the Akkar Plain (Dubertret 1962; Beydoun 1977: 333-335). In this area the Cenomanian-Turonian deposits contain limestone, chert, and geode quartz, while chert with chalcedony is found in the Senonian (Upper Cretaceous) and Lower Eocene deposits (Dubertret 1974: 376, 378, 1966: 308-309; Saint-Marc 1974: 201-202; Beydoun 1977: 329, 332-333). Therefore, the clay and sedimentary constituents in the matrix suggest a location along the northern coast of Lebanon. However, this region lacks volcanic outcrops that would produce basalts. A location where a river exists which drains an area with these sedimentary deposits and alkaline olivine basalts is the Akkar Plain of northern Lebanon (Dubertret 1962; Guerre and Sanlaville 1970: 22-26; Beydoun 1977: 322, 326, 328). The plain was created by the Nahr el-Kebir that brings in Pliocene age (a subdivision of the Neogene) volcanic inclusions from further inland (Dubertret 1974: 383-386; Beydoun 1976: 321, 1977: 334). The volcanic strata are between sedimentary layers and produce basalts of slightly different types due to the succession of depositional phases and the varying exposure to weathering. Thus, the interpreted area of production of the Group 1 samples is the Akkar Plain where the large MBA site of Tell ʿArqa is located (Fig. 5.9; Thalmann 2006).

The LBA cuneiform clay tablets, known as the Amarna Letters, identified as manufactured at Tell ʿArqa and Tell Kazel, on the northern half of the Akkar Plain, are similar in both clay and some sedimentary inclusions to Group 1. However, slight differences were noted in the appearance of the basalt fragments (Fig. 5.11; Badre and Gubel 1999-2000; Goren *et al.* 2003: 108-116, Plate V)[151]. This dissimilarity is probably the result of chronological differences in materials acquisition and/or the utilization of specific resources for clay tablets. Further, the manner by which outcrops containing volcanic

[151] All images of the Amarna tablets and Uluburun LBA Canaanite jar thin sections were taken while at the Laboratory for Comparative Microarchaeology at Tel Aviv University. They are reproduced here with the kind permission of Prof. Yuval Goren.

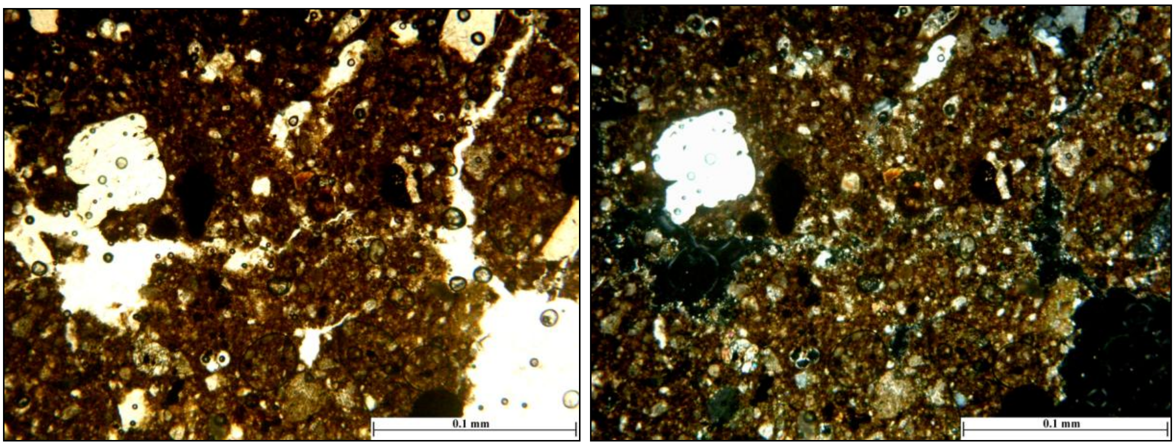
inclusions were cut by the Nahr el-Kebir may vary over space and time. However, an examination of a thin section from a MBA Levantine Painted Ware (LPW) jug believed to have been produced locally at Tell ʿArqa did show similarities between the basalts in this sample and those in the Group 1 sections[152]. Overall, the weight of the current evidence suggests the Group 1 samples were manufactured in the Akkar Plain.

Fig. 5.10: Photomicrographs of Group 1 thin section, 40x magnification, note black basalt inclusions




PPL XPL

Fig. 5.11: Photomicrographs of Amarna tablet thin section from Tell ʿArqa (EA 171), 100x magnification, note small basalt fragment at lower left

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[152] Ongoing petrographic examination of MBA LPW and Tell el-Yahudiyeh juglets from Tell ʿArqa is being conducted by the author.

### 5.3.2 Group 2 ("Inland Lebanon")

#### *5.3.2.1 Clay, mineralogy, and technology*

Based on the single grain foraminifera and the calcareous nature of the material, the samples in Group 2 are produced from rendzina (Wieder & Adan-Bayewitz 2002: 412). These soils, which develop directly upon limestone outcrops due to the Mediterranean climate, can also contain a fair amount of iron-rich components in addition to calcareous material (Bridges 1997: 73-75; Wieder & Adan-Bayewitz 2002: 397-406)[153]. The clay varies in colour from cream to brownish-red or reddish yellow, depending on the amount of iron-rich or calcareous material present. An iron-rich rendzina was used to manufacture the samples in Group 2. Inclusions comprise limestone, iron-stained chalk, chert, chalcedony, and geode quartz with inclusions from metamorphic strain (Fig. 5.12). The less common grains include quartz, polycrystalline quartz, biotite, muscovite, iron oxides, opaques, clay pellets, pyroxenes and serpentine. Some samples also contain feldspars, amphiboles, epidote, and rutile. The poorly sorted inclusions comprise 10% of the matrix, and are typically very fine to medium in size, although some are very coarse. The quartz/feldspar grains are subrounded to subangular in shape, very fine to medium in size, and occur either in a sparse or frequent amount. The frequent to abundant limestone inclusions are very fine to very coarse-sized and rounded to subrounded in shape. Chert grains are sparsely present in sizes very fine to coarse, and are subangular in shape. The section is medium red-brown under plane polarized light, and dark red-brown in cross polarized light. The optical activity is slight to active.

The intact limestone and chalk, along with the optical activity of the section, suggests a low firing temperature between 700°C and 800°C. The very fine calcareous fragments in the clay that grade up to very coarse size suggest that an unrefined rendzina was employed to manufacture the vessels. This is confirmed by the presence of limestone, iron-rich chalk, chert, and other sedimentary inclusions that could all be naturally present in clay derived from weathering limestone. The large size and slightly angular shape of the inclusions indicates the source of the materials was probably located close to the limestone outcrop, rather than coming from a reworked secondary deposit some distance from the parent rock. Overall, there is little evidence for the addition of temper or an involved process to prepare the materials for pottery production.

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[153] Within Lebanon these soils would be classified as a Xerorthents or Xerochrepts, see Ilaiwi 1985 for their distribution in Lebanon. The term rendzina is found in the English Soil Classification System (Bridges 1997: 47).

##### *5.3.2.2 Interpreted provenance*

Rendzina (Xerorthents or Xerochrepts)[154] is prevalent along the Lebanese coast where sedimentary outcrops also contain limestone, chalk, chert, chalcedony, and geode quartz inclusions (Dubertret 1962; Ilaiwi 1985). The chert with chalcedony inclusions derives from deposits of Senonian (Upper Cretaceous) or Lower Eocene age, while chert, limestone, and geode quartz can be found in Cenomanian-Turonian outcrops (Dubertret 1974: 376, 378, 1966: 308-309; Saint-Marc 1974: 201-202; Beydoun 1977: 322, 329, 332-333). Both are found predominantly along the coast of Lebanon. The Cretaceous deposits on the coast are typically more eroded north of Beirut, whereas further south these outcrops extend over a larger proportion of the Lebanese mountains (Fig. 5.7; Dubertret 1970: 13-14).

The absence of coastal sand inclusions in the Group 2 samples suggests that the location of production was slightly inland or possibly in an area that lacks coastal sand deposits. Along the Lebanese coast, the area from Sidon to north of Tripoli, with the exception of a small area south of Beirut, has limited beaches with the mountains rising sharply only a few kilometres from the shore (Guerre & Sanlaville 1970: 21). The site of Byblos is close to sedimentary outcrops and lacks significant deposits of coastal sand (Dubertret 1962; Beydoun 1976: 313-314). Macroscopic examination of sherds from this site indicates that their fabric is similar to the Group 2 samples (Kopetzky pers. comm.). Furthermore, Byblos was known to have traded with Egypt during this period (Montet 1928). Examination of LBA Amarna tablets believed to have been manufactured at Byblos did not provide exact matches; however, some of the samples did feature rendzina soil, limestone, chert, chalcedony, and geode quartz, all of which are characteristic of Group 2 (Fig. 5.13; Goren *et al.* 2003: 134-169, Plate VII). The examination of local MBA pottery from this site would greatly assist in determining if this is indeed the origin of the Group 2 samples. For now, the interpreted provenance of Group 2 is inland Lebanon, based on the fact that this group lacks coastal material and includes constituents common to sedimentary outcrops in the Lebanese Mountains (Fig. 5.9).

[154] Xerorthents are weakly developed soils (Entisols) that form under a Mediterranean semi-arid climate where they are mostly dry in the summer months, but wetter in the winter months. Xerochrepts form under the same climatic conditions but are more developed (Inceptisols). These terms derive from the International Soil Taxonomy System (Bridges 1997: 51-54).

Fig. 5.12: Photomicrographs of Group 2 thin section, 40x magnification, note iron-stained chalk fragments

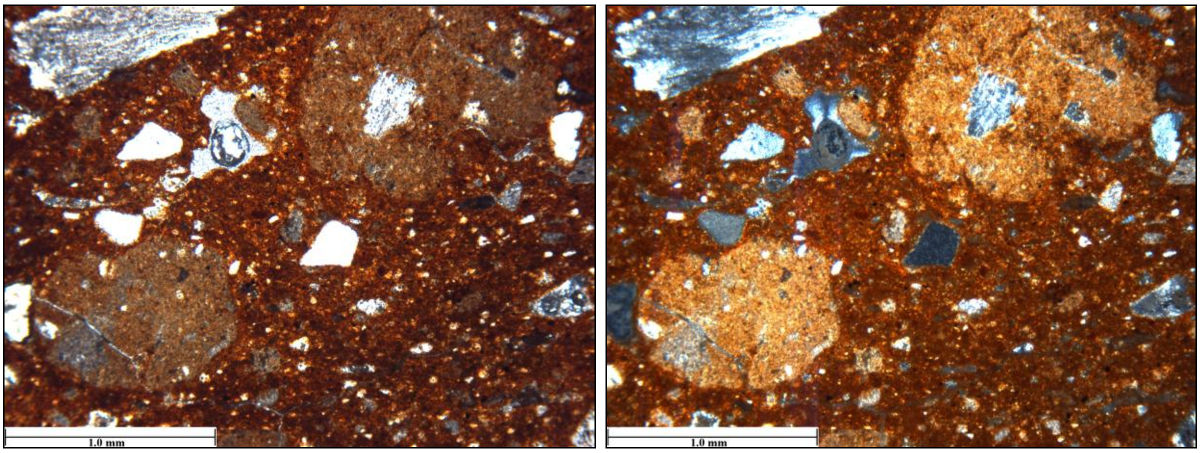


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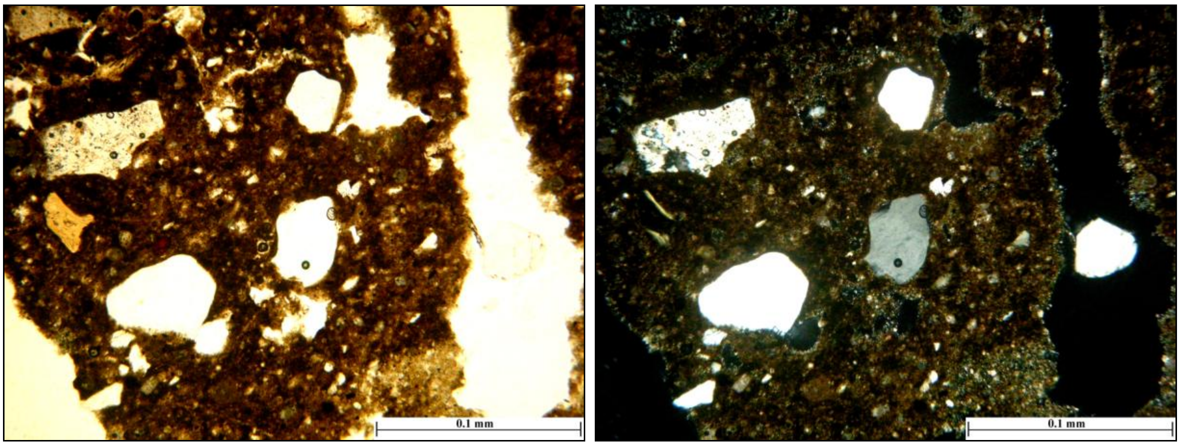
Fig. 5.13: Photomicrographs of Amarna tablet thin section from Byblos (EA 129), 100x magnification, note chalcedony inclusion at upper left

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### 5.3.3 Group 3 ("Coastal Lebanon")

#### *5.3.3.1 Clay, mineralogy, and technology*

Rendzina was also identified as the clay utilized in the Group 3 samples (Wieder & Adan-Bayewitz 2002: 412). A variety of rendzina soils with colours ranging from pale to reddish yellow were used. A few samples were produced from a foraminiferous marl clay, probably derived from the weathering of a foraminifera-rich limestone. Both clay types contain the same set of inclusions comprising bioclasts, particularly of the *Amphiroa* species of alga, limestone, chert, chalcedony, and geode quartz with inclusions (Fig. 5.14). Also present are quartz, polycrystalline quartz, feldspars, biotite, muscovite, iron oxides, opaques, clay pellets, epidote, pyroxene, and serpentine. Some samples contain amphiboles, olivine, and tourmaline.  The sorting of these inclusions is poor and typically they comprise 10% of the matrix, although their frequency ranged from 5% up to 30%.  Most of the grains are very fine to medium in size, with only some coarse to very coarse.  The sparse to frequent quartz/feldspar grains are usually very fine to coarse-sized and subangular to subrounded in shape.  Limestone fragments are subrounded to rounded in shape, exist in sizes from very fine to very coarse, and can be either sparse, frequent or abundant.  The very fine to coarse-sized chert inclusions are typically rare and subangular in shape.  In plane polarized light, the sections appear medium tan or medium red, while in cross polarized light they are dark tan or dark red.  The majority of the samples are optically slightly active.

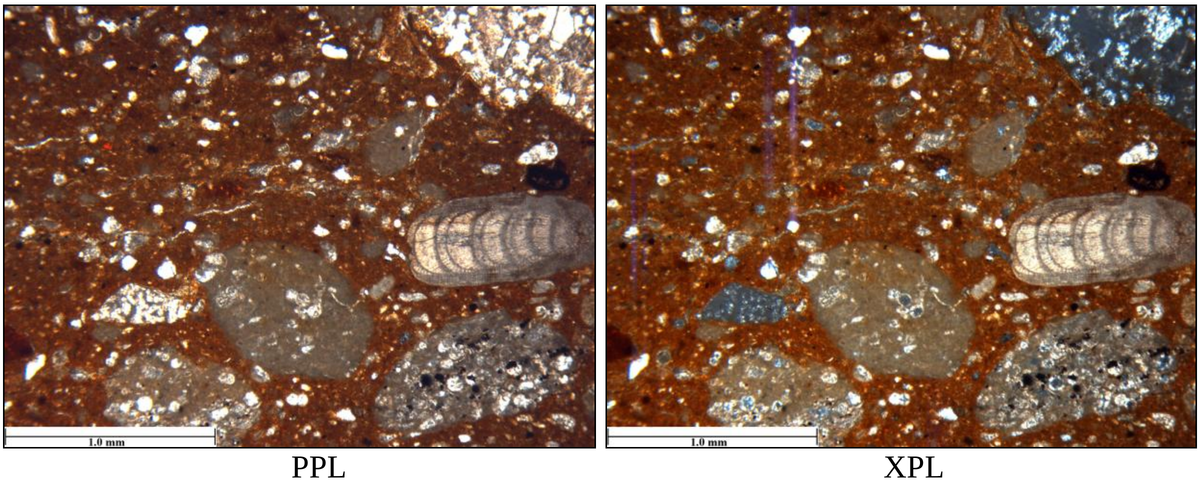
The firing temperature is estimated at between 700°C and 800°C, based on the optical activity of the matrix and the lack of decomposed limestone or bioclasts.  The grading of the calcareous component from small to large sizes suggests that the materials were not refined; rather clays with naturally existing limestone, chert, chalcedony, and geode quartz were utilized.  Possibly, the clays may have been carried to the coast where, as a secondary deposit, they acquired inclusions indicative of the coast.  This would explain the rounded shape of the sedimentary inclusions and the variability seen in the amount of bioclasts.  However, a few samples appear to have had a small amount of coastal sand added that included some of the sedimentary components.  In general, there is great variety in these samples probably resulting from a lack of processing of the materials and the production of the jars at several localities.

#### *5.3.3.2 Interpreted provenance*

The most obvious feature of the Group 3 samples is the bioclasts within the matrix that clearly indicate a coastal origin for the jars.  The rendzina, foraminiferous marl clay, and sedimentary inclusions confirm that the area of production was near limestone outcrops (Dubertret 1962; Ilaiwi 1985).  The chert, chalcedony, and geode quartz, deriving from deposits of Senonian (Upper Cretaceous) or Lower Eocene, and Cenomanian-Turonian age, indicate the Lebanese coastal region (Dubertret 1974: 376, 378, 1966: 308-309; Saint-Marc 1974: 201-202; Beydoun 1977: 322, 329, 332-333).  The Eocene deposits containing chert are common north of Tripoli, and in the region between Sidon and Tyre.  Furthermore, the Quaternary age coastal sediments in Lebanon often contain high amounts of bioclasts, including *Amphiroa* species alga clasts (Buchbinder 1975: 45-46).  In contrast, beach sand south of Akko tends to have more quartz and feldspar grains and lacks the chalcedony and geode quartz inclusions (see section 5.3.4.2).  The Lebanese coastal sand was formed by the drainage of rivers from inland.  Thus, beach sands are present near rivers that have a consistent flow carrying significant amounts of sediment.  This occurs in several areas: south of Tyre to just north of Sidon (due to the Nahr Litani), around Beirut (due to the Nahr Beirut), and around Tripoli (due to the Nahr el-Kebir) (Wetzel 1945; Dubertret 1949; Beydoun 1976: 312-314, 318-322)[155].

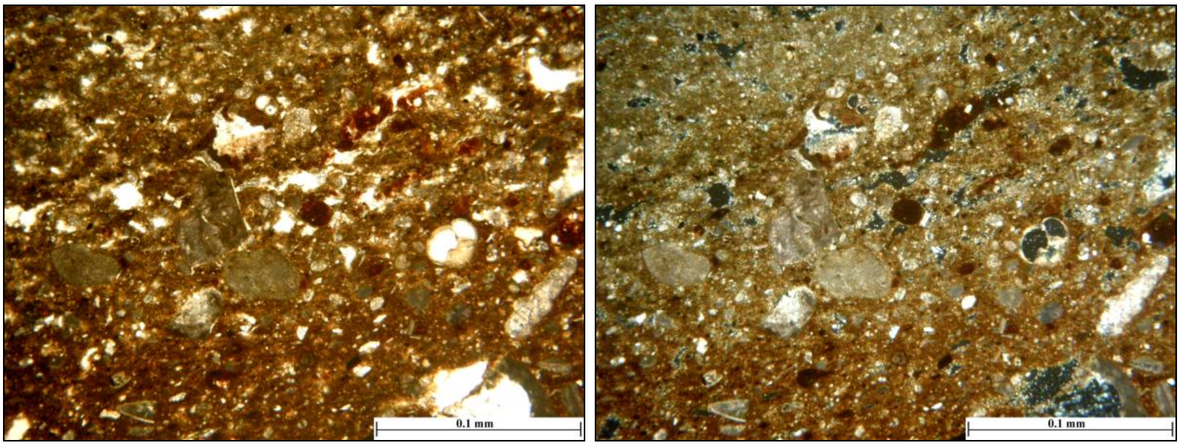
The variation in the samples indicates several locations of manufacture along the coast of Lebanon, with the large MBA sites of Sidon and possibly Beirut as likely provenance candidates (Badre 1997; Doumet-Serhal 2004b).  The sedimentary inclusions in the Group 3 samples are similar to those in LBA Amarna tablets originating from these sites (Goren *et al.* 2003: 134-169, Plate VII).  Examination of thin sections of LBA Canaanite jars from the Uluburun shipwreck identified as deriving from the coast of Lebanon revealed many samples with similar coastal sand, however, the clays were often different and more varied probably due to chronological changes in production (Fig. 5.15).  Several MBA jars from the site of Sidon appear similar to these samples, possibly suggesting that production of the jars was in this area[156].  However, the examination of coastal sand from Sidon did not assist in positively identifying this site as the location of manufacture, due to the utilization of unrefined materials for vessel production (Ownby & Griffiths 2009).   Without further evidence, such as material from a MBA kiln in this region, the interpreted provenance is based predominantly on the mineralogical data and is suggested as the coast of Lebanon (Fig. 5.9).

Fig. 5.14: Photomicrographs of Group 3 thin section, 40x magnification, note *Amphiroa* alga clast at middle right




[155] Petrographic analysis of beach sand from Sidon and Tell el-Burak (Ownby and Griffiths 2009) also suggests the sand derives from inland rivers with sediments generally deposited near outlets or slightly north.
[156] Examination of Sidon thin sections was conducted through the generosity of Dr. Claude Doumet-Serhal and Dr. Dafydd Griffiths, who provided valuable comments.

Fig. 5.15: Photomicrographs of LBA Canaanite jar thin section from the Uluburun shipwreck (KW 372), 100x magnification, note bioclasts

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### 5.3.4 Group 4 ("Coastal Northern Palestine")

#### *5.3.4.1 Clay, mineralogy, and technology*

Group 4 samples are produced from a brown rendzina, although some samples appear to have *Terra Rossa* as an additional component[157] (Wieder & Adan-Bayewitz 2002: 395-406). The dominant inclusions are quartz and bioclasts, including a few *Amphiroa* species alga clasts (Fig. 5.16). Less common grains of polycrystalline quartz, feldspars, both plagioclase and K-feldspars, limestone, iron oxides, opaques, clay pellets, chert, epidote, pyroxene, and serpentine also occur. Some samples contain biotite, muscovite, amphibole, olivine, kyanite, and organic plant remains. One sample, Ownby 8, contains a fresh holocrystalline alkali olivine basalt fragment[158]. The inclusions are fairly sorted and comprise 10% of the matrix, being roughly equal parts quartz/feldspar grains and bioclasts. The typical size range is very fine to medium, although occasionally coarse to very coarse fragments are present. The frequent quartz/feldspar grains are from subangular to rounded in shape, and from very fine to medium in size. Limestone inclusions are very fine to very coarse in size, only sparsely present, and mostly rounded in shape. The subrounded chert fragments are rare in the matrix and fine to medium-sized. Under plane polarized light the sections are red-brown to brown, while in cross polarized light they appear dark red-brown to dark brown. The samples are slightly optically active.

[157] Ownby 11 was made of a *Hamra*, an iron-rich soil found along the central coast of Palestine (Dan *et al*. 1975; Gvirtzman *et al*. 1998; Sneh *et al*. 1998b; Porat *et al*. 2004).
[158] Basalt consisting of inclusions of plagioclase, olivine, and pyroxenes, with very little glass (Allaby & Allaby 2003: 263).

The intact limestone fragments and the optical activity of the matrix suggest these samples were fired between 700°C and 800°C. While the rendzina may have contained some limestone and chert grains, most of the inclusions appear to be a coastal sand temper with equal proportions of quartz grains and bioclasts. However, without an investigation of how secondary deposits of rendzina exist along the coast and their interaction with beach sand, it remains difficult to unequivocally state that the samples in this group were intentionally tempered with coastal sand. The variability in the samples probably indicates that for some vessels, coastal sand was a temper, while for others the sand may have been naturally present in the clay. Several samples show the addition of *Terra Rossa* soil, revealing that the potter combined two clay resources and then may have added coastal sand temper. The addition of *Terra Rossa* to other clays is a common practice for potters in the Levant.

##### *5.3.4.2 Interpreted provenance*

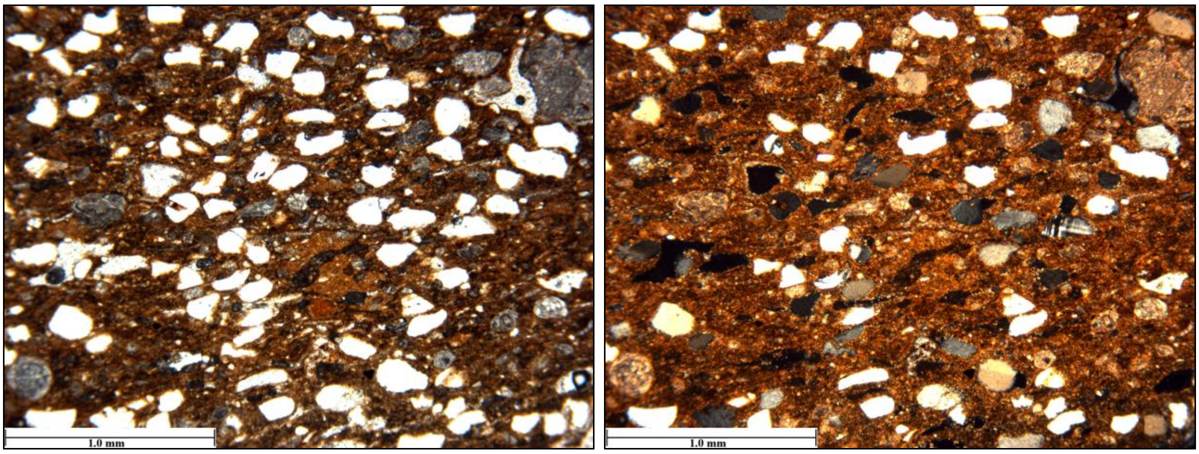
As both rendzina and *Terra Rossa* are found throughout the Levantine region, they do not aid in establishing a provenance for these samples. The rendzina was probably from secondary deposits of alluvial soils along the coastal plain, while *Terra Rossa* is typically found further inland (Dan *et al*. 1975). The coastal sand, composed of roughly 50% quartz grains and 50% bioclasts, suggests that the vessels were produced along the northern coast of Palestine (Emery & Neev 1960: 6-7, 10-11; Sivan *et al*. 1999: 283). In this region, the Quaternary beach sand has a higher quartz content than the sands found north of Akko, where the bioclasts dominate (Buchbinder 1975: 45-46; Sivan 1996: 6). These particular quartz grains derive from the emptying of the Nile River into the Mediterranean and currents that flow mostly northwards carrying the grains along the coast of Palestine up to Haifa Bay. Here, the reduced wave action causes most of the remaining sediment to be deposited, i.e. Haifa Bay is a sediment sink (Goldsmith & Golik 1980: 147-151, 156-173). This phenomenon results in large, angular grains in beach sands on the southern coast, while further north the quartz grains are smaller and rounder. Additionally, rare and large bioclasts are found in the southern coastal sand, while prevalent, smaller bioclasts are in the northern beach sand. Therefore, the beach sand on the northern Palestinian coast features equal amounts of quartz grains and bioclasts of roughly the same size[159].

A sand of this description appears to have been utilized as temper with a calcareous clay to produce some probably local MB IIA Canaanite jars at Tel Nami (Marcus 1995). The LBA Canaanite jars from the Uluburun shipwreck identified as manufactured along the

[159] The alkali olivine basalt grain in sample Ownby 8 is probably from the recently exposed Upper Cretaceous deposits in the Carmel Ridge due to its fresh appearance and type (Sass 1980: 11, 21; Sneh *et al*. 1998a).

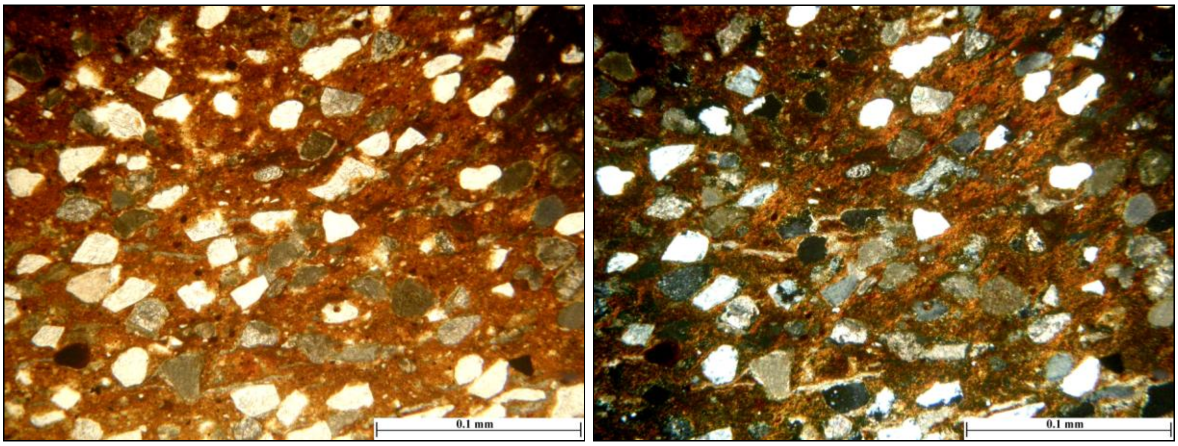
northern Palestinian coast were similar to Group 4. However, some of the LBA samples were made of a different clay and more clay types were noted (Fig. 5.17)[160]. While the MBA sites of Tel Nami and Akko are likely production locations for the Group 4 samples, the interpreted provenance must remain generally the northern coast of Palestine (Fig. 5.9; Artzy 1993; Dothan 1993).

Fig. 5.16: Photomicrographs of Group 4 thin section, 40x magnification, note prevalence of white quartz grains




PPL XPL

Fig. 5.17: Photomicrographs of LBA Canaanite jar thin section from the Uluburun shipwreck (KW 652), 100x magnification, note quartz grain amount

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[160] No Amarna tablets were produced in this area, so comparison was made only to the LBA Canaanite jars from the Uluburun shipwreck.

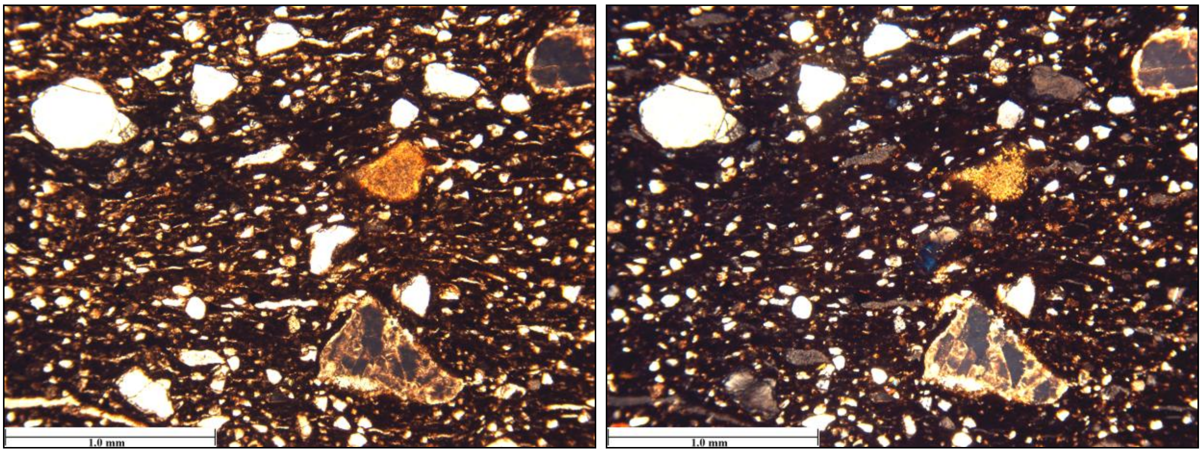
### 5.3.5 Petrographic outliers

#### *5.3.5.1 Ownby 48*

Within the material studied here, there were several individual samples that were assigned to areas outside of the four groups described above. For example, sample Ownby 48 features common angular, silt-sized (0.0039-0.0625mm) quartz grains in the matrix that are indicative of loess. This soil is fairly iron-rich and is the product of wind-blown sediments. Other inclusions are larger grains of quartz and kurkar, a calcium cemented quartzitic sandstone, and limestone (Fig. 5.18). Less common inclusions are polycrystalline quartz, K-feldspars, plagioclase, biotite, muscovite, microfossils, iron oxides, opaques, amphibole, chert, epidote, olivine, pyroxene, and serpentine. The sorting is poor and the inclusions, typically in sizes very fine to medium, comprise only 5% of the matrix. Quartz/feldspar grains are abundant, particularly in very fine to medium sizes, and are subangular in shape. The frequent limestone grains are usually of subrounded shape and are very fine to very coarse-sized. The subangular chert inclusions are very fine to fine-sized, and quite rare. The section is medium reddish-brown in plane polarized light, dark reddish-brown in cross polarized light, and optically active.

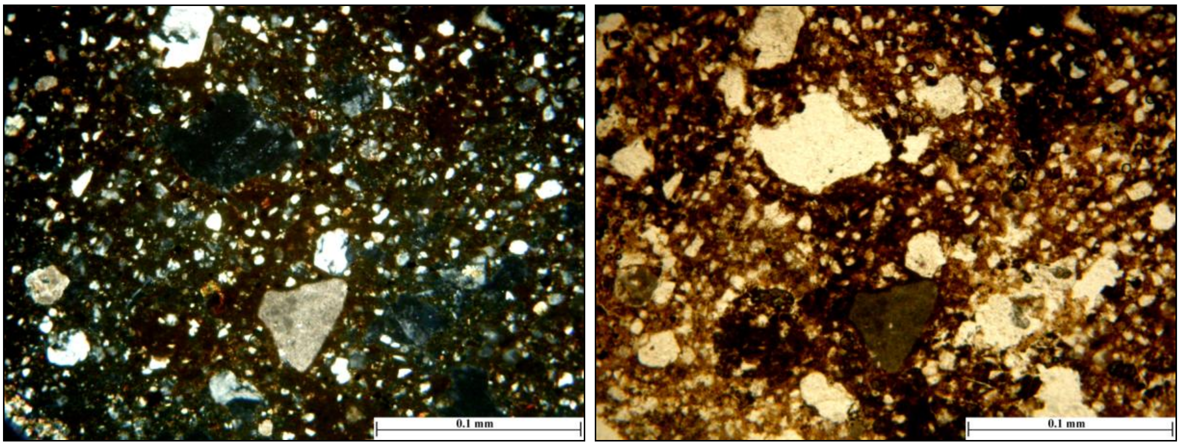
This sample was low fired, from 700°C and 800°C, and produced from loess combined with material from a weathering kurkar outcrop, which produced kurkar fragments, loose quartz grains and some smaller inclusions of limestone. There is a possibility that a deposit with a mixture of loess and weathered kurkar naturally exists that would have provided the raw materials for the vessel with no refinement or addition of other resources. Loess is predominantly distributed in southern Palestine, particularly along the coast from Sinai to Ashdod (Yaalon & Dan 1974: 334; Dan *et al*. 1975). The presence of kurkar in this sample suggests a coastal area is more likely, since ridges of this rock type are found along the Palestinian coast (Gvirtzman *et al*. 1998; Sneh *et al.* 1998b; Porat *et al*. 2004). The presence of kurkar and loess suggests an interpreted provenance for Ownby 48 in southern coastal Palestine, possibly at the important MBA site of Ashkelon or slightly inland closer to the kurkar ridges (Fig. 5.9; Stager 1993). An Amarna tablet from this site appears similar in terms of the loess used in its manufacture (Fig. 5.19; Goren *et al.* 2003: 294-299, Plate XII).

Fig. 5.18: Photomicrographs of Ownby 48 thin section, 40x magnification, note kurkar fragment at lower right




PPL XPL

Fig. 5.19: Photomicrographs of Amarna tablet thin section from Ashkelon (EA 324), 100x magnification, note fine quartz grains

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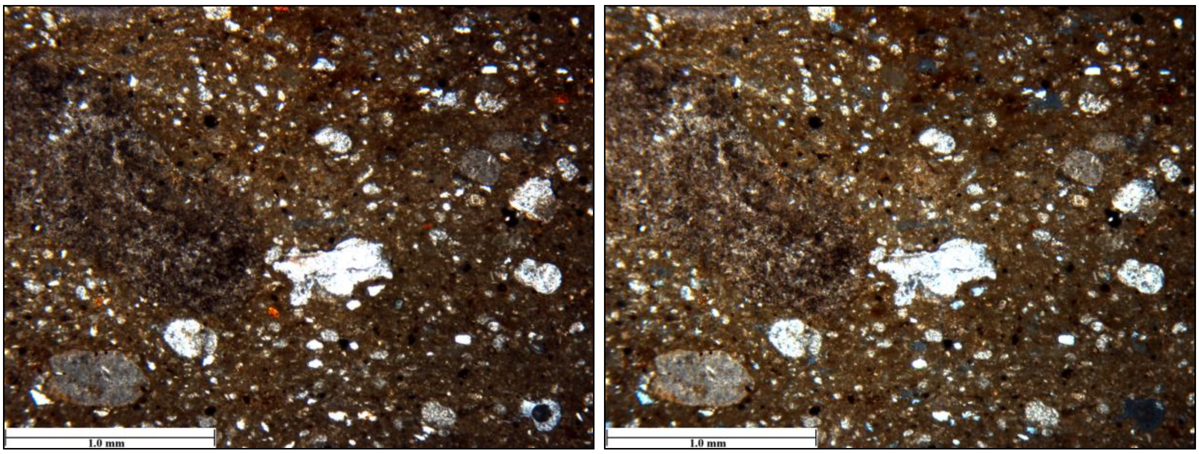
#### *5.3.5.2 Ownby 7*

The prevalent foraminifers and calcareous nature of the clay in sample Ownby 7 suggests it was manufactured from a foraminiferous marl, but with the addition of *Terra Rossa*. The inclusions consist of limestone, travertine, and nari (a calcareous crust that forms on limestone outcrops), along with less common quartz, plagioclase, microfossils, shell, iron oxides, opaques, amphibole, chert, pyroxene, serpentine, and organic plant remains (Fig. 5.20). The matrix features very poorly sorted inclusions in sizes from very fine to medium, with a frequency of 5%. The very fine to fine-sized quartz/feldspar grains occur sparsely in subrounded to rounded shapes. Limestone of rounded shape is abundant in sizes from very fine to very coarse. The very rare chert grains are fine-sized and are rounded in shape. A slightly optically active section is medium brownish-grey in plane and cross polarized light.

The intact limestone fragments and slightly optically active matrix indicate the firing temperature was between 700°C and 800°C. The presence of limestone in all size ranges strongly suggests a marl clay eroding from a foraminiferous limestone outcrop was utilized directly to produce the vessel. There is no evidence for the refinement of the clay or the addition of temper materials beyond the *Terra Rossa*. The exclusively sedimentary inclusions do not permit identification of an exact provenance. However, the chert and limestone are possibly of Eocene or Lower Cretaceous age, while nari is common in Eocene deposits, but is also found in reworked soil eroded from these outcrops (Wieder & Adan-Bayewitz 2002: 397-400). The lack of coastal material eliminates the coast as a possible origin. The marl clay suggests that the production location was not in southern Palestine. The petrographic analysis of Pottery Neolithic ceramics from sites in northern Palestine has revealed the utilization of a foraminiferous marl clay with natural inclusions of limestone and nari (Goren and Cohen-Weinberger 2002: 435). The origin of this material is believed to be from Senonian marl outcrops in the Galilee area, and suggests a possible area of production for Ownby 7. However, there is a large time gap between the Pottery Neolithic samples and the MBA Canaanite jar sample. As the distribution of Eocene outcrops is extensive in Palestine and Lebanon, the interpreted provenance for this sample is the inland Levant (Dubertret 1962; Sneh *et al.* 1998a, and b). Additional petrographic analysis of pottery manufactured from foraminiferous marls may lead to a more precise identification of the area of production.

Fig. 5.20: Photomicrographs of Ownby 7 thin section, 40x magnification, note fragment of limestone at centre left

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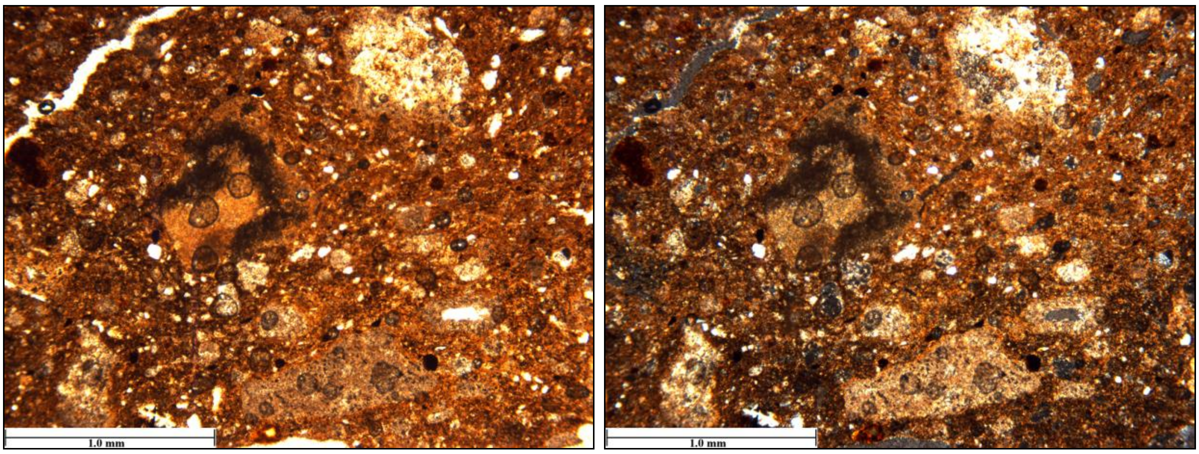
#### *5.3.5.3 Ownby 15*

Sample Ownby 15 was produced of rendzina with *Terra Rossa*. Limestone is the dominant inclusion, along with less prevalent quartz, plagioclase, microfossils, iron oxides, opaques, clay pellets, chert, pyroxene, serpentine, and very weathered volcanic rock fragments (probably basalt) composed mostly of plagioclase (Fig. 5.21). The poorly sorted inclusions comprise 5% of the matrix and are typically from very fine to medium in size. The sparse quartz/feldspar grains are very fine to fine in size and are subrounded in shape. Rounded limestone fragments are also sparsely present and are very fine to very coarse-sized. Very fine to very coarse-sized chert in subangular shapes is only very rarely encountered. The section in plane polarized light is medium brown and dark brown in cross polarized light. The matrix is slightly optically active.

This sample was probably fired around 700°C to 800°C. The large limestone grains suggest that the clay had not been altered to remove oversized inclusions and temper was not added. Thus, a rendzina close to its parent source or only slightly reworked as a secondary deposit was utilized directly, with the addition of *Terra Rossa* as the only modification. Both rendzina and *Terra Rossa*, along with the sedimentary inclusions, are wide spread. Manufacture on the coast is not likely due to the absence of coastal sediments, while the presence of weathered basalts suggests a region near volcanic outcrops. This limits the area to most likely the Jezreel Valley or Upper Galilee. However, comparable material has not appeared in the examination of thin section collections, so the interpreted provenance can only be given as the general inland Levant. Further, this area would need to be near volcanic outcrops.

Fig. 5.21: Photomicrographs of Ownby 15 thin section, 40x magnification, note small basalt fragment in lower left

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*5.3.5.4 Ownby 25*

Sample Ownby 25 was manufactured from a calcareous clay reddish in colour containing large argillaceous inclusions and decomposed limestone. The other inclusions comprise quartz, polycrystalline quartz, K-feldspar, plagioclase, biotite, muscovite, iron oxides, opaques, clay pellets, amphibole, epidote, pyroxene, serpentine and fragments of quartzite (Fig. 5.22). These inclusions are poorly sorted and are present as 5% of the matrix. Their sizes range from very fine to medium, with rare inclusions of coarse to very coarse size. The quartz/feldspar grains are subrounded, very fine to medium in size, and occur sparsely. Very fine to very coarse-sized limestone inclusions are sparse in the matrix and normally subrounded in shape. Chert grains are not present. The section is dark reddish brown in plane polarized light and very dark reddish brown in cross polarized light, while lacking any optical activity.

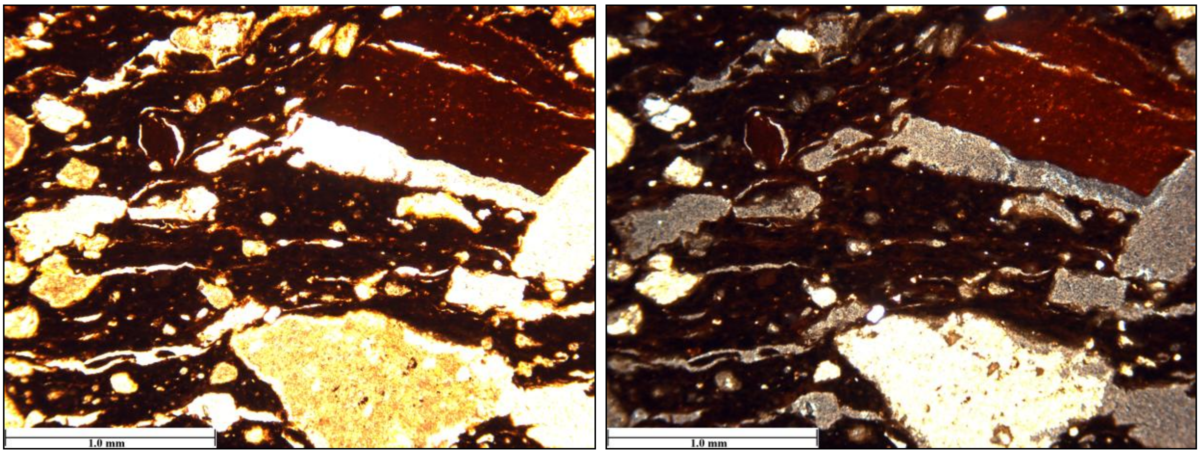
The decomposed limestone and lack of optical activity of the matrix suggests this sample was fired from 850°C to 900°C, making it unusual as far as the typical firing temperature for MBA Canaanite jars is concerned. Dry clay lumps were probably ground for only a short amount of time to prepare the clay, leaving large argillaceous inclusions (Griffiths & Ownby 2006). The addition of a minor amount of sand, seen in the quartz, quartzite, and feldspar grains, and some limestone is clear. The clay, inclusions, and firing temperature of this vessel indicate the vessel was not produced in the Levant. The clay is known as a marl clay, the product of weathered limestone, and most closely resembles those utilized to produce Marl C vessels in Egypt (Nordström & Bourriau 1993: 179-181). Examination of thin sections from Marl C ceramics revealed similarities to Ownby 25 in appearance and constituents (Cyganowski 2003: 35-45). The argillaceous inclusions and decomposed limestone indicate it would be classified as Marl C1.

Marl C vessels are found predominantly in the Delta and Memphis-Fayum region during the Middle Kingdom and Second Intermediate period (Nordström & Bourriau 1993: 179-181). Reproductions of Canaanite jars are known in Nile silt in the Second Intermediate Period strata at Tell el-Dab$^{c}$a (strata E/1 to D/2 in Areas A/I-IV and Stratum a/2 in Area F/I), along with one produced from a Marl clay (Bietak 1991a: 44-46, Fig. 13; Aston 2004a: 240-241; Kopetzky 2004: 252, 265) [161]. Aston (2004a: 241) notes the existence of Marl Canaanite jar fragments from Tell el-Maskhuta and a Marl C handle from Lisht, while during the early 18$^{th}$ Dynasty Marl C Canaanite jars were found at Tell Hebwa. Therefore, the Egyptians

[161] The petrographic analysis of MBA Canaanite jars at Tell el-Dab$^{c}$a did not identify any jars made of Egyptian materials, however, those mentioned were not selected for analysis (Cohen-Weinberger & Goren 2004: 92-98).

probably copied the MBA Canaanite jar shape in local fabrics because large vessels with handles, although unknown in the native ceramic repertoire, would have been useful in daily life.  While Ownby 25 could provide further confirmation of the production of Canaanite jars in Marl fabrics, the sample was a body sherd so linking it definitively to a Canaanite jar shape is not possible.

Fig. 5.22: Photomicrographs of Ownby 25 thin section, 40x magnification, note argillaceous inclusion at upper right

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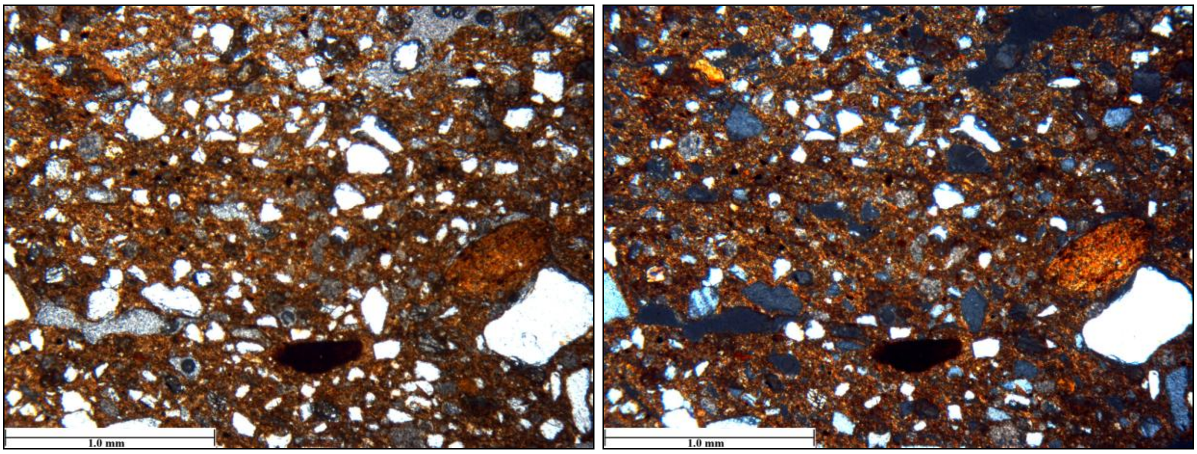
*5.3.5.5 Ownby 12*

A marl clay was also employed in the production of sample Ownby 12.  Inclusions in the matrix comprise quartz, polycrystalline quartz, K-feldspar, plagioclase, biotite, limestone, iron oxides, opaques, amphibole, epidote, pyroxene, and sphene (Fig. 5.23).  The poorly sorted constituents are usually found in sizes fine to medium and comprise 10% of the matrix. Quartz/feldspar grains are frequent, very fine to very coarse-sized, and subrounded in shape. The limestone fragments are very fine to very coarse in size, rounded in shape, and only sparsely present.  The optically active matrix is light to medium brown in plane polarized light and light to medium tan in cross polarized light.

The optically active matrix and intact limestone fragments indicates a firing temperature probably between 700°C and 800°C.  The clay was almost certainly excavated as dry pieces that were cursorily ground for use, leaving large argillaceous fragments as natural inclusions.  Sand and some limestone were added as temper.  The marl clay is similar to those in Egypt used to manufacture vessels of fabric Marl A2, which also features argillaceous rock fragments (Nordström & Bourriau 1993: 176).  Comparison to thin sections of Marl A2 showed some similarities (Bourriau & Nicholson 1992: 45-49).  Marl A2 ceramics are known in the Middle Kingdom but become more common in the late Second Intermediate Period and early New Kingdom (Nordström & Bourriau 1993: 176). As Ownby 12 is a body sherd there is no possibility for confirming if Marl A2 was employed to produce local Canaanite jars.

Fig. 5.23: Photomicrographs of Ownby 12 thin section, 40x magnification, note argillaceous inclusion middle right

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### 5.3.6 General Levant samples

Several samples were produced from materials that are commonly distributed in the Levant, and/or not diagnostic for a particular area. Thus, their provenance is suggested to be the general Levant[162]. However, none of the samples include coastal material, so an inland Levantine region is more likely. While some of the previous outlier samples were given this designation, their clay and inclusions provide the possibility for further narrowing the interpreted provenance, whereas the samples within this group do not possess that potential. Ownby 27 is made from *Terra Rossa* with quartz, polycrystalline quartz, limestone, iron oxides, opaques, clay pellets, amphibole, epidote, pyroxene, and serpentine in the matrix. The inclusions are poorly sorted, comprising 10% of the matrix, and typically range from very fine to medium-sized. Frequent quartz/feldspar grains are subrounded and very fine to fine-sized. Rounded limestone fragments are abundantly present in very fine to very coarse sizes. The section is medium tan to red-brown in plane polarized light and dark tan to red-brown in cross polarized light. The optical activity of the sample and intact limestone suggest a firing temperature between 700°C and 800°C. Production of this vessel was minimal with only the addition of some limestone to a *Terra Rossa*.

[162] See Appendix II for images of these samples.

Ownby 38 was produced from a brown rendzina and includes grains of quartz, polycrystalline quartz, K-feldspar, muscovite, limestone, iron oxides, opaques, clay pellets, amphibole, chert, epidote, pyroxene, serpentine, and tourmaline. The poorly sorted inclusions are usually very fine to medium in size and constitute 5% of the matrix. The sparsely distributed quartz/feldspar inclusions are very fine to medium in size and subangular in shape. The subrounded limestone fragments are sparse and range in sizes from very fine to coarse. Fine to medium-sized chert grains are subangular and very rare. The matrix is slightly optically active, medium tan in plane polarized light and dark tan in cross polarized light. The clay was left unrefined, containing some natural quartz and limestone inclusions, and was fired from 700°C to 800°C.

Ownby 46 was manufactured from rendzina and *Terra Rossa*, containing inclusions of quartz, polycrystalline quartz, K-feldspar, plagioclase, limestone, iron oxides, opaques, clay pellets, amphibole, geode quartz, epidote, pyroxene, serpentine, and tourmaline. These constituents comprise 5% of the matrix and are poorly sorted. Most grains are very fine to medium in size. Subangular quartz/feldspar inclusions are frequent and very fine to coarse-sized. The frequent limestone fragments are very fine to very coarse in size and rounded. Chert is not present. The section in plane polarized light is medium tan to brown and dark tan to brown in cross polarized light. The firing temperature was between 700°C and 800°C. Beyond the mixing of rendzina and *Terra Rossa*, the materials do not appear to have been refined or tempered in any manner.

Lastly, Ownby 47, was produced from *Hamra* soil with inclusions of quartz, polycrystalline quartz, K-feldspar, plagioclase, biotite, muscovite, limestone (some with small quartz grains), iron oxides, opaques, clay pellets, amphibole, chert, epidote, pyroxene, and serpentine. The typically very fine to medium-sized grains are poorly sorted and comprise 10% of the matrix. Quartz/feldspar inclusions in sizes from very fine to coarse are subangular in shape and occur frequently. The subrounded limestone fragments are frequent and very fine to very coarse-sized. Chert is not present. An optically inactive matrix is medium brown in plane polarized light and dark brown in cross polarized light. The decomposing limestone and optically inactive matrix indicate that the firing temperature was probably from 850°C to 900°C. Little temper appears to have been added to a clay that was probably a secondary deposit containing natural inclusions. The *Hamra* soil and fine quartz grains present in some of the limestone fragments suggests a region just inland from the coast of northern Palestine as a possible provenance (Sivan 1996; Sneh *et al*. 199b; Dan *et al*.

1975). However, the interpreted provenance, like the other samples in this group, must remain the general inland Levant.

### 5.3.7 Point count data

The point count data acquired from the thin sections assisted in clarifying the similarities and differences between the groups. The frequency of the major inclusions of quartz, limestone, and chert along with the amount of matrix was plotted for the samples in each group[163]. The results for Group 1 confirmed that limestone and chert were more common than quartz (Fig. 5.24). For Group 2, limestone was more prevalent than quartz and chert (Fig. 5.25). A similar pattern was apparent for most of the samples in Group 3, along with noticeable variability in the amount of chert (Fig. 5.26). Group 4 samples showed a more equivalent quantity of quartz and limestone with little chert in only a few samples (Fig. 5.27). These data confirmed the visual impression of the variability within the individual groups, while also highlighting the differences between the groups. For example, limestone is a major constituent for Groups 2 and 3, while it is less common in Groups 1 and 4. Chert inclusions also have a higher frequency in Groups 2 and 3. Clearly, each group exhibits a unique pattern for the frequency of these major inclusions relating to their location of production. Finally, these data reveal that although the inclusion amounts varied, the percentage of matrix was typically around 70-80% for all samples. These observations suggest a similar method of production, where the clay dominated and inclusions, although large, comprised a minor component.

[163] The frequency of the other recorded inclusions was typically between 1-5%.

Fig. 5.24: Point Count data from MBA Group 1 samples

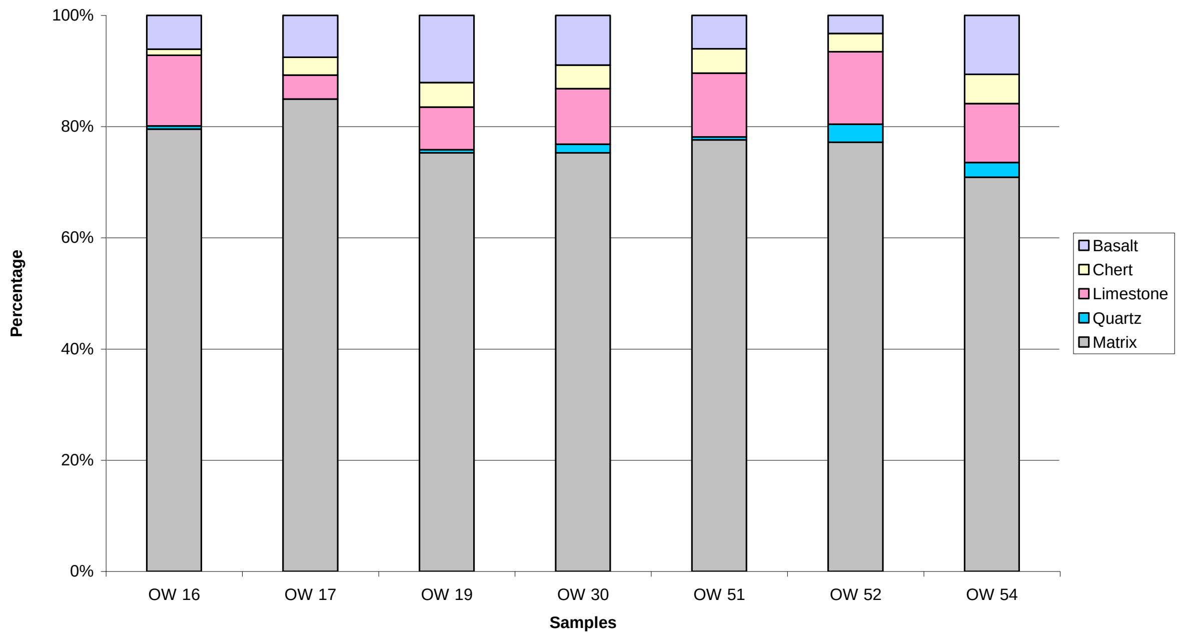



Fig. 5.25: Point Count data from MBA Group 2 samples

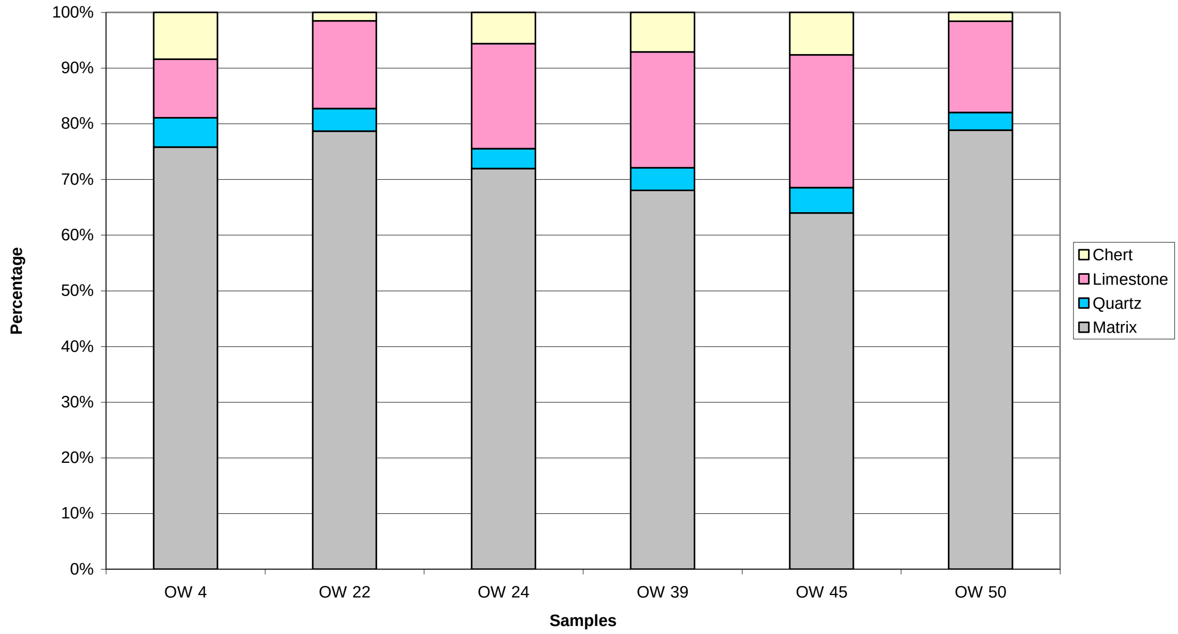


Fig. 5.26: Point Count data from MBA Group 3 samples

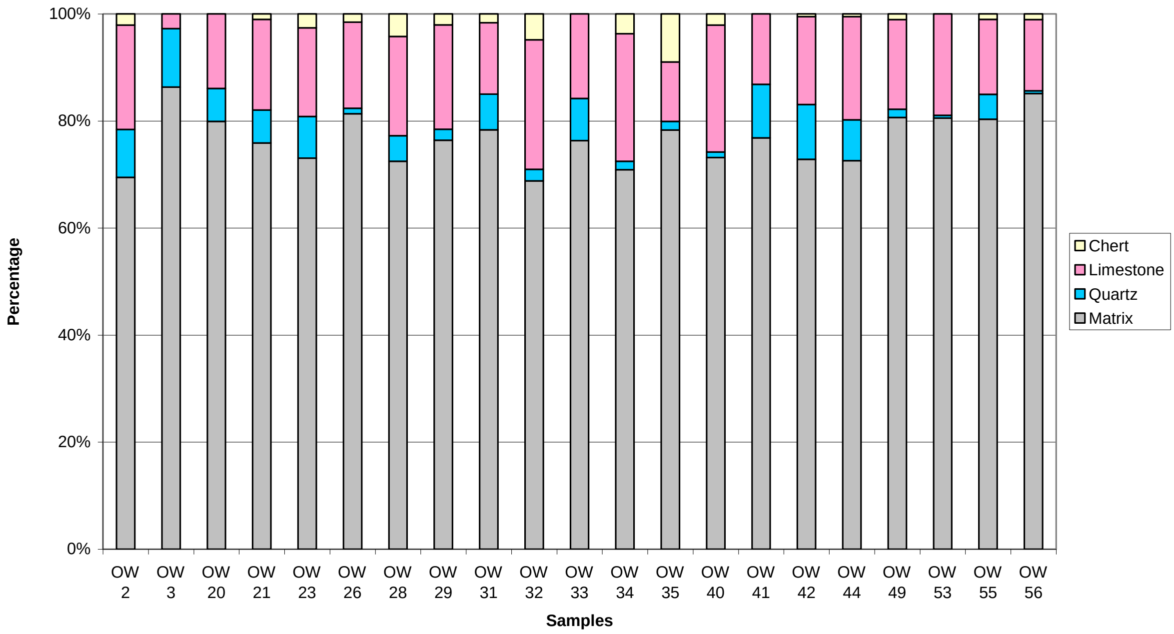
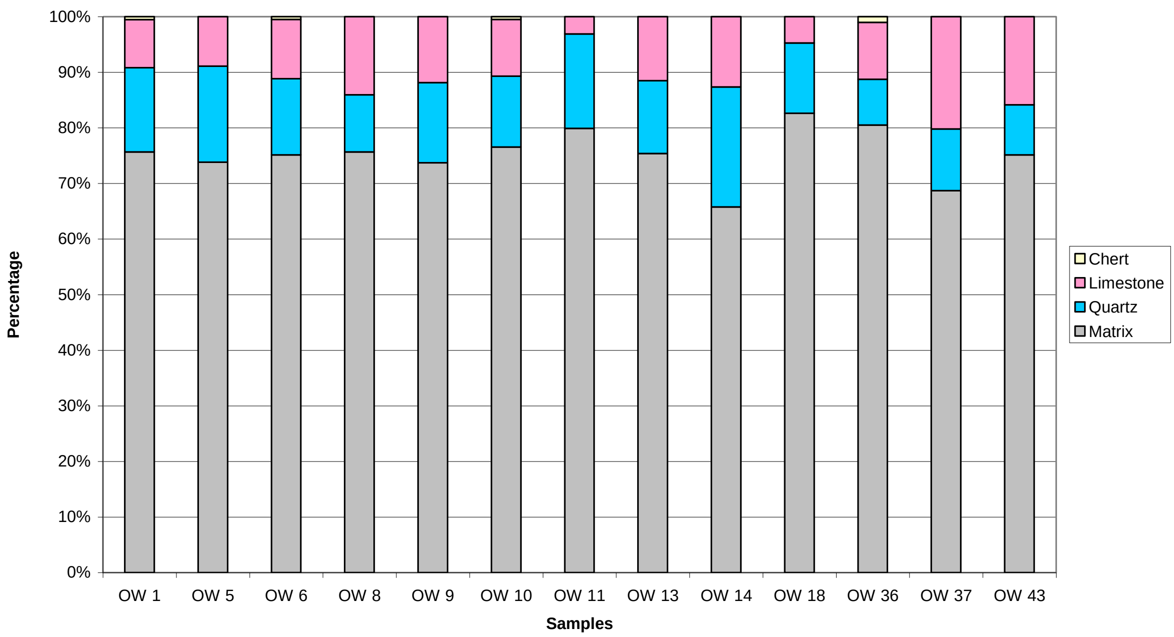



Fig. 5.27: Point Count data from MBA Group 4 samples



## 5.4 *Chemical Analysis Results*

### 5.4.1 Utility of the data

Before any chemical compositional data can be used to investigate a group of ceramic samples, the accuracy and precision of the data must be examined (Bishop *et al*. 1990)[164]. The accuracy of the ICP-AES data was investigated by comparing the results from the current analysis of laboratory standards to their "known" values. Additionally, for both the ICP-AES and ICP-MS data, the international ceramic standard SARM 69 was used. Examination of the results from the laboratory standards indicated that most of the elements had percentages of error below 10%, which is considered an acceptable level of error (Appendix III, Tables III.1 and III.2). However, some elements had a higher percentage of error, namely Cr, Mn, Ni, P, V, and Zn, for some of the standards. The data from the analysis of SARM 69, further suggested that the accuracy of these elements may be problematic. For the ICP-MS data, published SARM 69 values were only available for some of the elements, Ce, Cr, Co, Rb, Sc, and Th, but have not been established for the remainder (i.e. Cs, Dy, Eu, Hf, La, Lu, Sm, Ta, U, and Yb). For those elements with known concentrations, their percentages of error were below 10% except for Sc. Both ICP-AES and ICP-MS yielded data on the element Cr. In order to establish which data to use, the values from both analyses were compared to the published Cr concentration in SARM 69. Since the ICP-MS Cr level was closer to the established value, its results were used for the statistical analysis of the data.

The data's precision was assessed by calculating the relative standard deviation (RSD) for the repeat analyses of each sample, which should ideally be between 1% and 3%. For the ICP-AES data, the elements Cr, Ni, and V exhibited higher RSD for some samples, indicating that their analysis was less precise, which probably contributed to the accuracy difficulties. Likewise, ICP-MS data for Cs, Eu, and Lu proved problematic for some of the samples (Appendix III, Table III.4). Two other factors may have contributed to variation in the data (Hart *et al*. 1987: 579-580). The first related to the ability of lithium metaborate fusion to completely dissolve the samples[165]; and the second was the natural compositional variability within the sherds. To assess the first issue, powdered sample material from the same sherd was divided in half, with each half digested and analyzed separately. To investigate the second problem, two separate pieces for each of six sherds were taken for analysis. The results from both approaches were compared in the same way as the

[164] The methods are outlined in Appendix I, while the raw data are in Appendix III.
[165] See section 4.5.4 for a discussion of this technique and difficulties involving the complete dissolution of the ceramic powder.

assessment for accuracy, i.e. the absolute error and percentage of error were calculated. The elements that proved to have low accuracy and precision were also problematic for repeat analyses of the same powder (e.g. Cr, Cs, Lu, Ni, and V) (Appendix III, Tables III.3 and III.4). Comparing the results from the analyses of two samples from the same sherd revealed generally good agreement, indicating that the data from the samples are representative of the sherd as a whole (Appendix III, Tables III.5 and III.6). Once again, those elements that proved to have accuracy and precision problems also had higher percentages of error for the comparisons (e.g. Cs, Lu, Mn, Ni, V, and Zn). The elements Ba, Hf, Sr, and Ta had high percentages of error, but were not shown in the investigations of accuracy and precision to be difficult to determine. However, data for assessing the accuracy of Hf and Ta were lacking. This may indicate that these four elements are rare and unevenly dispersed in the ceramics, making their repeat determination problematic.

For the existing NAA data, precision was examined through the multiple analyses of one sample and calculating the standard deviation and relative standard deviation as described above[166]. The results revealed that Cs, K, Rb, Ta, and Yb had difficulties due to experimental errors in the analysis (Al-Dayel 1995: 88). Additionally, different samples were taken from six sherds to assess the extent to which the analyses were representative of the ceramic composition. The results suggested that only Mn was not uniformly distributed in the samples creating problems in the data (Al-Dayel 1995: 89-91). Al-Dayel believed that this was probably due to manganese oxides that tend to form unevenly dispersed nodules in the ceramic. The accuracy and precision assessment for all of the data were important for selecting elements that truly represent the chemical variability within the samples. The information provided by these investigations was subsequently utilized when selecting elements for statistical analysis

### 5.4.2 Combined ICP and NAA data

NAA data was available for 22 of the MBA Canaanite jar samples from the work by Al-Dayel (1995), while in the current study ICP data had been acquired for 34 additional samples. The elemental concentrations for the six samples that had both NAA and ICP data were plotted together and a best-fit regression line using the least squares method was produced (Shennan 1997: 131-139). This created an equation transforming the ICP data into values comparable to the NAA data (see Appendix I for statistical method). Then, the

[166] Mention is not made in the publication of any tests carried out to assess accuracy through the analysis of established standards.

combined data were transformed into base 10 logarithms, as this form of adjustment has proven to be the most appropriate for ceramic compositional data (Bishop & Neff 1989: 63, 72; Baxter 2003: 75). This data set was initially examined through both principal components analysis (PCA) and hierarchical cluster analysis (HCA)[167]. For graphical representation, the samples were assigned to their petrographic group, with Group 1 the "Akkar Plain" samples, Group 2 the "Inland Lebanon" samples, Group 3 the "Coastal Lebanon" samples, Group 4 the "Northern Coastal Palestine" samples, and the remaining samples put into Group 5 (consisting of outliers and those assigned to the "General Levant"; although when the outliers were removed for some analyses the group consisted only of those termed "General Levant").

The PCA results showed no recognizable pattern when the samples were plotted along the first three components (Fig. 5.28). This was not surprising, as analysis by PCA of the individual ICP and NAA data sets, carried out initially to ensure the data were useable before being combined, had also not shown a strong grouping of samples[168]. The elements contributing variability to the first three principal components (PCs) are listed in Table 5.3 and accounted for 72% of the variability[169]. The petrographic examination had identified samples Ownby 7, Ownby 12, Ownby 15, Ownby 25, and Ownby 48 as unique. These "outliers" were removed for the second PCA[170]. Further, elements that showed good accuracy and precisions for the NAA and ICP data sets, and had a high correlation coefficient when the data were plotted against each other (see Appendix I), were selected for the analysis[171]. The elements Al, Ca, Ce, Co, Dy, Fe, Hf, La, Na, Sm, Th, Ti, and U were used and 82% of their variability was accounted for by the first three PCs. Some of the same elements that were important for the first analysis also contributed to the PCs for the second analysis (Table 5.4). However, there was no improvement in clustering the samples by their assigned petrographic group (Fig. 5.29).

[167] The specifications for each statistical test are given in Appendix I.
[168] These initial tests also identified sample outliers that were removed for some of the statistical analyses.
[169] An analysis is considered good if the total variance accounted for by the first three PCs is higher than 70% (Baxter 2001: 686).
[170] Removal of outliers, particularly those identified by independent means, can ensure that their unusual compositional data does not obscure the variability in the samples and prevent archaeological meaningful results from being produced (Baxter 2003:123-127). These outliers had also appeared during the statistical investigations of the independent ICP data.
[171] Reducing the number of variables is often an advisable step in multivariate analysis of compositional data. More interpretable results are typically obtained by removing inaccurate and imprecise variables, and those not assisting in finding structure in the data (Baxter & Jackson 2001).

Fig. 5.28: PCA of combined MBA ICP and NAA data, all elements and samples

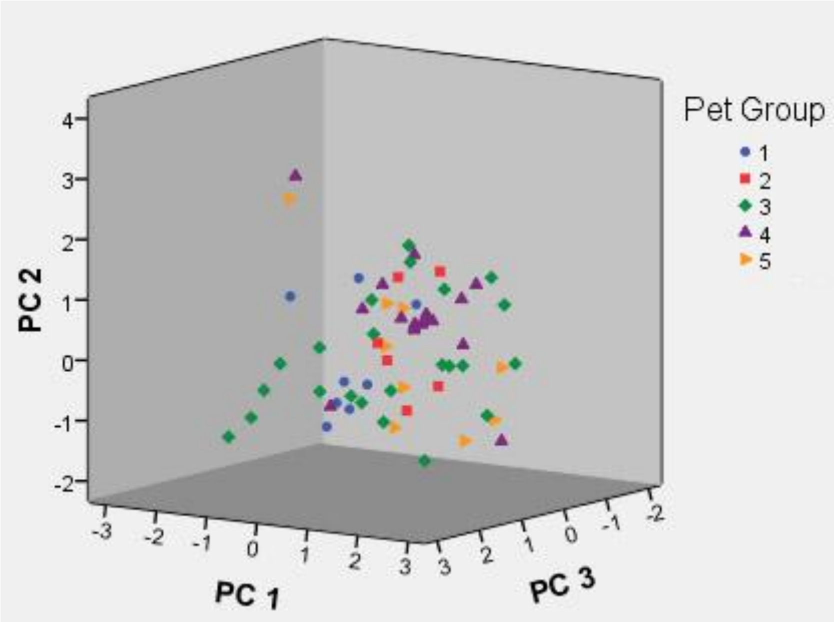



Table 5.3: Elements contributing variability to the first three components, combined MBA ICP and NAA data, all elements and samples

| PC 1 | PC 2 | PC 3 |
|---|---|---|
| Al, Ce, La, Rb, Sc, Sm, Th | Fe, Lu, U,Yb | Cr, Hf, U |

Fig. 5.29: PCA of combined MBA ICP and NAA data, select elements and samples

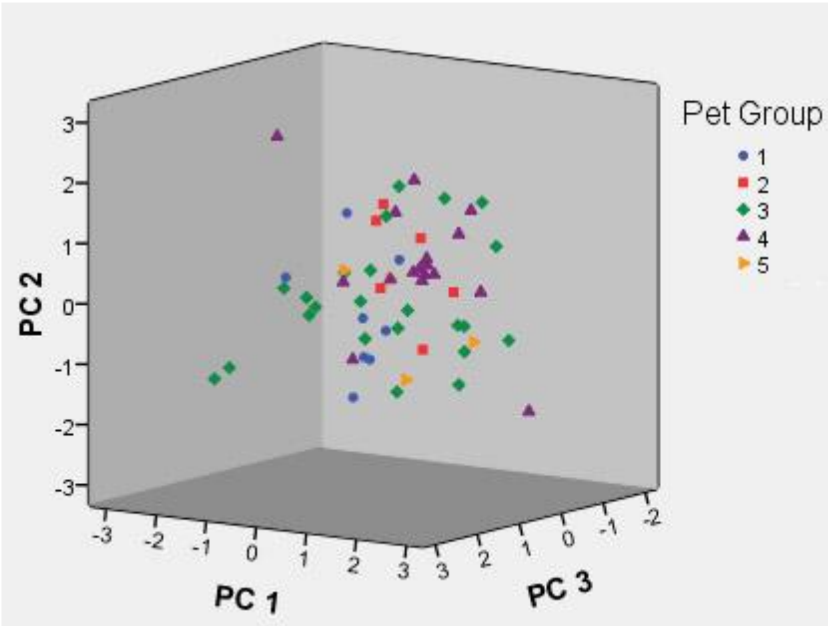


Table 5.4: Elements contributing variability to the first three components, combined MBA ICP and NAA data, select elements and samples

| PC 1 | PC 2 | PC 3 |
|---|---|---|
| Al, Ce, Hf, La, Sm, Th, Ti | Dy, Fe, U | Ca |

The next test, HCA, was useful in examining the quality of the data based on the placement of the repeat analyses in the same cluster (Fig. 5.30). The results revealed that many of the repeat analyses appeared in separate clusters, indicating an inability to reconcile the ICP data with the NAA data. When a second HCA was performed, after eliminating the problematic elements and outliers, the results were slightly improved but there were still repeat analyses from the same sample that were separated (Fig. 5.31). Additional hierarchical cluster analyses were performed with various permutations, however, none of the statistical approaches placed all of the samples' analyses together as expected. This issue was of concern, as examining the data from all of the samples together would identify similarities and differences between them as a group.

Fig. 5.30: HCA of combined MBA ICP and NAA data, all elements and samples (colour reflects petrographic group assignment as above for the PCA)

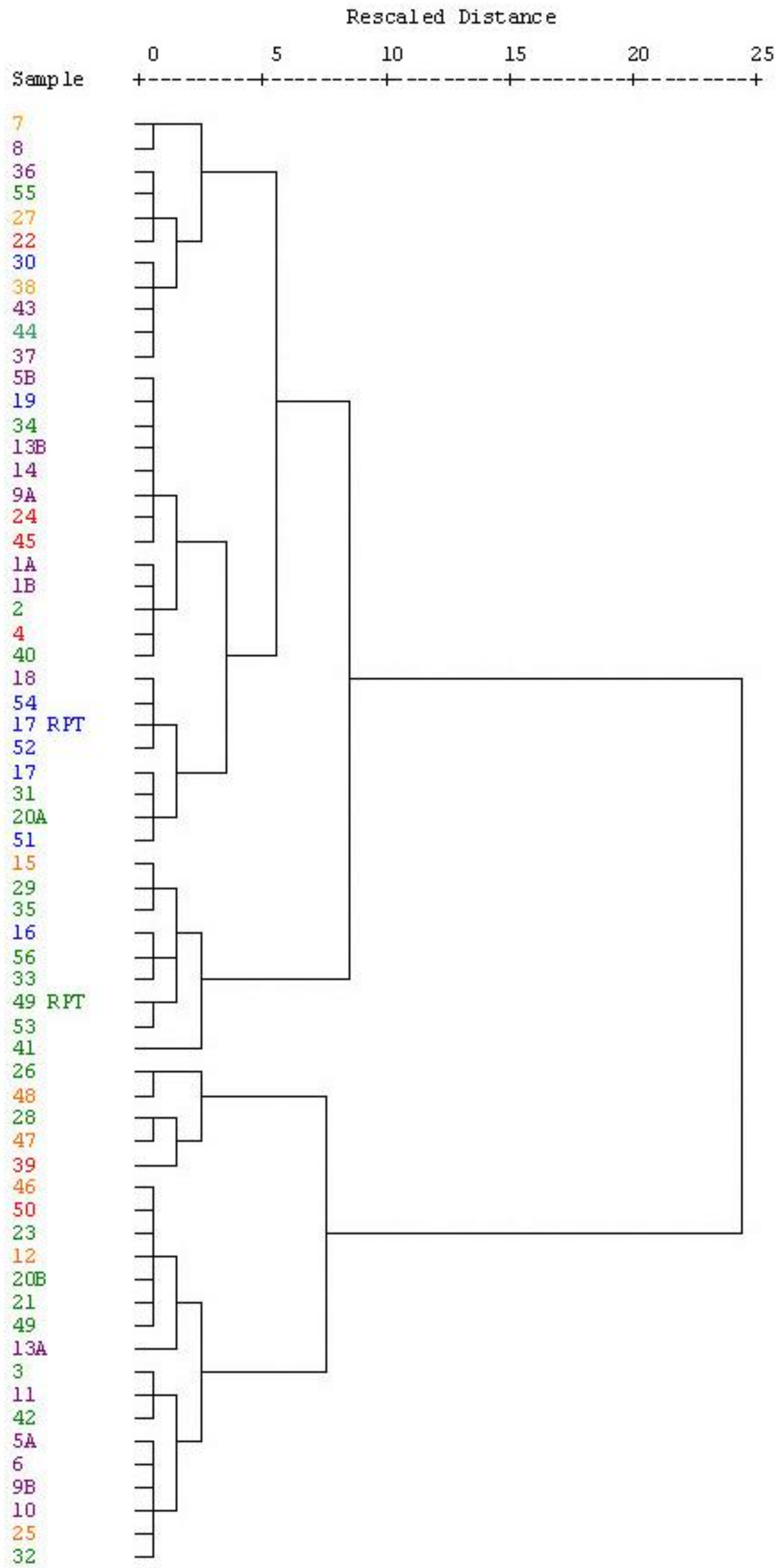
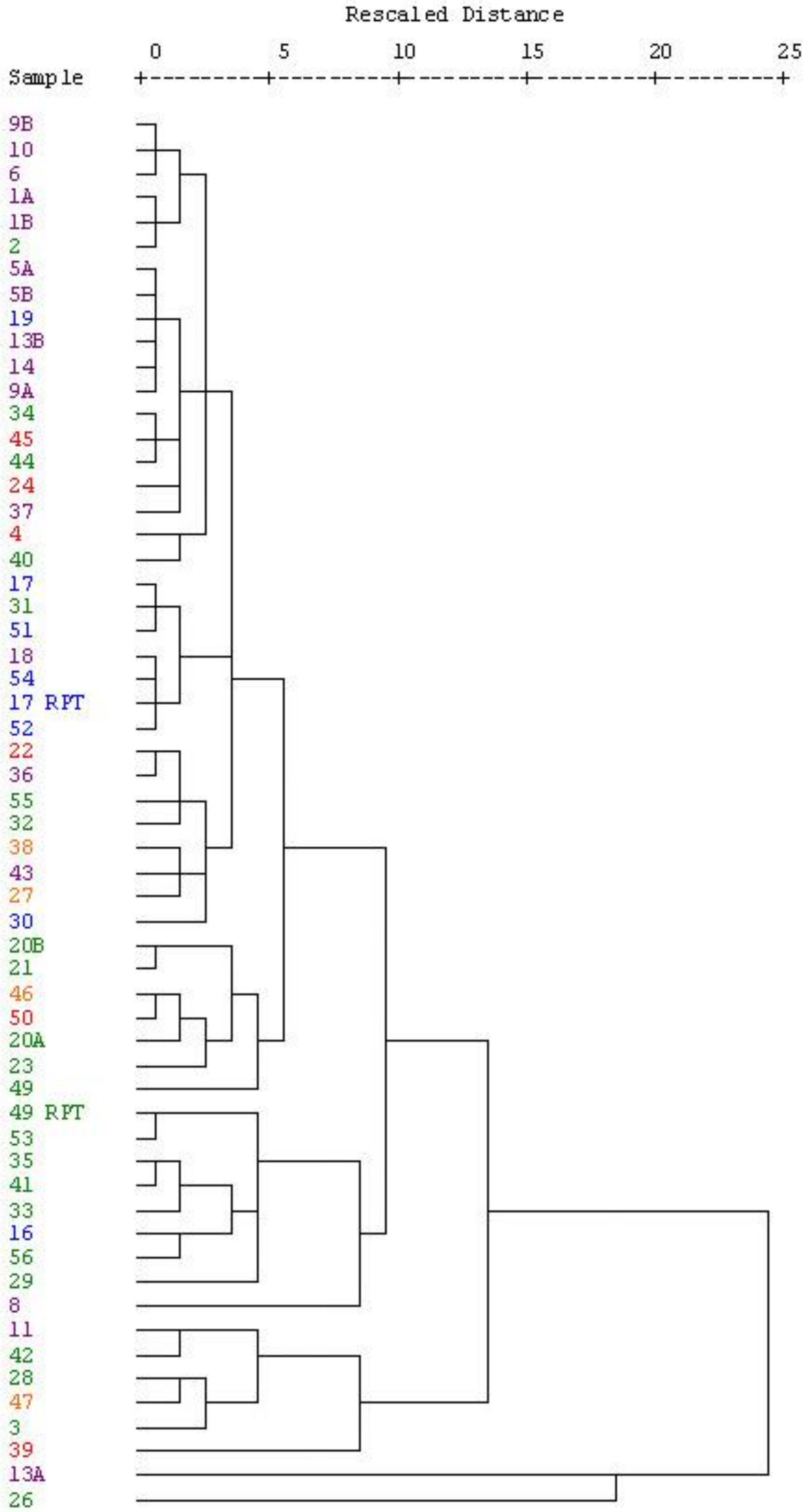


Fig. 5.31: HCA of combined MBA ICP and NAA data, select elements and samples



During examination of the individual ICP and NAA data, good results had been achieved with discriminant analysis; this test was thus performed on the combined data. The first run with all of the elements and samples showed a good amount of overlap between the groups, while a second test with the difficult elements and outliers removed also showed mixing of the samples (Fig. 5.32 and 5.33). In summary, the attempt to combine the ICP and NAA data had not been successful. The ICP and NAA data were subsequently examined separately by the statistical tests, utilizing the petrographic data to link the results.

Fig. 5.32: DA of combined MBA ICP and NAA data, all elements and samples

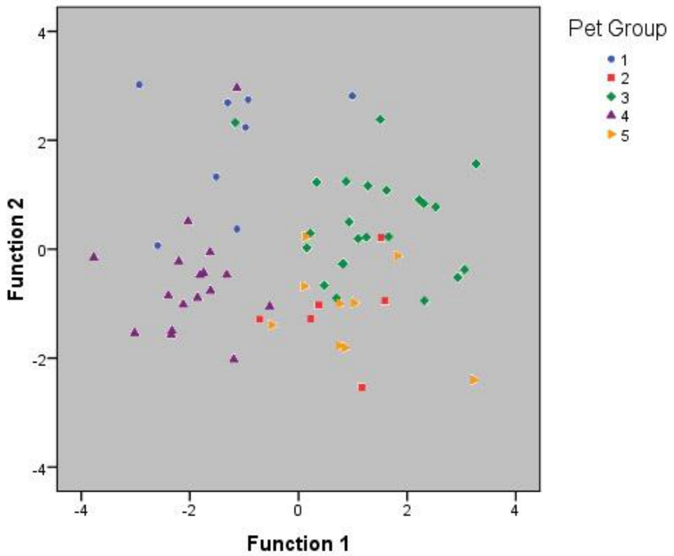
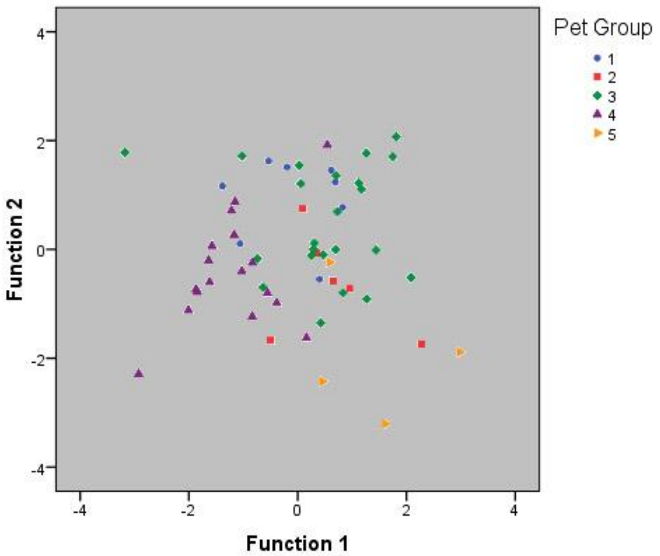



Fig. 5.33: DA of combined MBA ICP and NAA data, select elements and samples



### 5.4.3 ICP data

Once again, the samples were assigned to their petrographic groups (i.e. Group 1="Akkar Plain", Group 2="Inland Lebanon", Group 3="Coastal Lebanon", Group 4="Northern Coastal Palestine", and Group 5=outliers) for analysis and subsequent graphical representation. The statistical analyses of the ICP data also began with PCA. The graph of the first three principal components (PCs) showed only a slight amount of grouping within the data (Fig. 5.34). While, many elements were contribution variability, these three components only accounted for 70% of the variability in the data (Table 5.5). Based on the results from the investigation of the accuracy and precision of the ICP data, a second PCA was run eliminating Cr, Cs, Eu, Lu, Mn, Ni, Sc, V, and Zn[172]. P was removed as well since this highly mobile element is not considered reliable for compositional analyses (Freestone *et al.* 1985). The first PCA suggested that removing these elements would still leave other elements with useable variability. Additionally, the outliers identified during the petrographic analysis were removed. The "General Levant" samples were kept, as the chemical analyses may indicate they are related to one of the groups, particularly as trace elements in clays may show affinities not affected by the addition or lack of other materials. The second PCA, without the outliers and the problematic elements, showed a slight improvement in the grouping of the samples (Fig. 5.35). Most of the same elements were important contributors of variability (Table 5.6). Since these three components accounted for 79% of the variability, this analysis was more effective in representing the patterns in the data.

[172] Removing elements, even those shown to have lower than expected accuracy and precision can cause problems in statistical investigations of the data if they still contain important variability for separating the samples. Since this is not known before the statistical investigations begin, they are best left in the initial analyses until their removal is shown not to adversely affect the results of the tests.

Fig. 5.34: PCA of MBA ICP data, all elements and samples

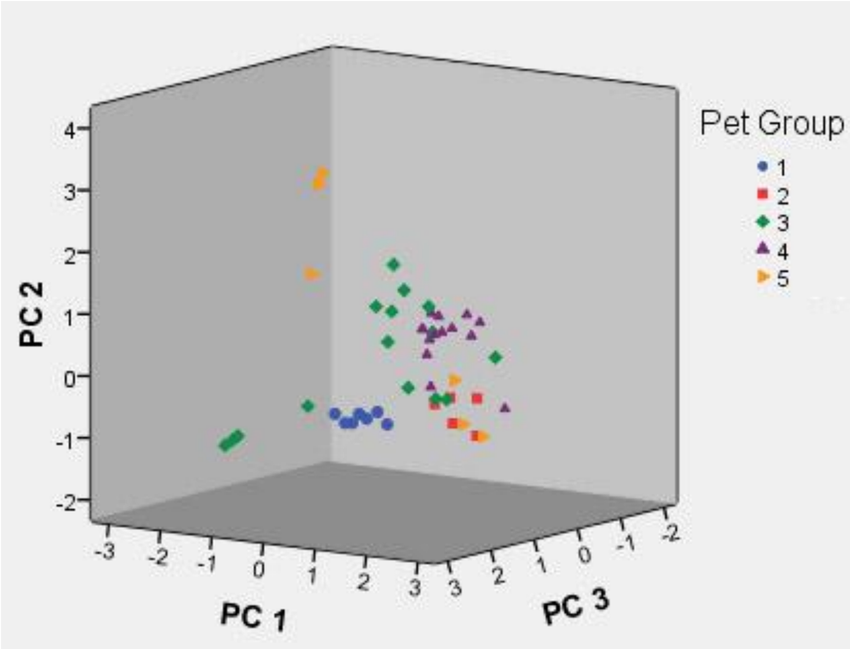



Table 5.5: Elements contributing variability to the first three components, MBA ICP data, all elements and samples

| PC 1 | PC 2 | PC 3 |
|---|---|---|
| Al, Ce, Dy, Eu, La, Rb, Sc, Sm, Ta, Th, Yb | Ba, Fe, Lu, P, V, Zn | Cr, Mg, Sr, U |

Fig. 5.35: PCA of MBA ICP data, select elements and samples

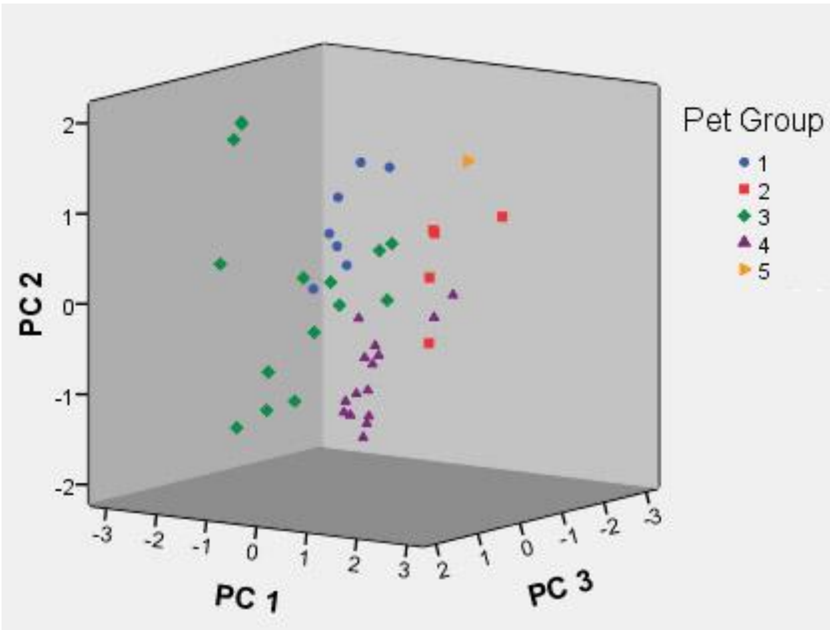


Table 5.6: Elements contributing variability to the first three components, MBA ICP data, select elements and samples

| PC 1 | PC 2 | PC 3 |
| --- | --- | --- |
| Al, Ce, Dy, Hf, La, Rb, Sm, Ta, Th, Yb | Ba, Fe, Ti | Si, Sr, U |

The HCA of the ICP data followed a similar procedure, with analysis first done with all samples and all elements. The results were slightly problematic for the first analysis, although for the most part the samples grouped as expected (Fig. 5.36). Significantly, the repeat samples from the same sherd were all placed in the same cluster. This test also revealed that samples Ownby 7, Ownby 15, and Ownby 25 were outliers. Surprisingly, samples Ownby 49, Ownby 53, and Ownby 56, classified by petrographic analysis as in Group 3 (Coastal Lebanon), were shown here to be a subset of that group. When a HCA was run that excluded the outliers and the problematic elements, the same subset of Group 3 appeared (Fig. 5.37). This suggests that while petrographically the three samples can be assigned to the Coast of Lebanon, they were apparently made of materials different from the other samples interpreted as produced in this area. While most of the Group 4 samples were in a single cluster well separated from the other groups, a few samples from Group 4 were placed in other groups. This is probably due to similarities in a few elements among these samples and those in the other groups, although the petrographic evidence suggests they were produced in another area. The large cluster with samples from Groups 1, 2 and 3 may be the result of these groups containing inclusions derived from the Lebanese mountains and lacking significant amounts of quartz, unlike Group 4. Overall, the results generally confirmed the petrographic grouping of the samples and revealed that certain samples were chemically different from other samples in the same group.

Fig. 5.36: HCA of MBA ICP data, all elements and samples (colour of samples related to the petrographic groups as specified for the other statistical tests)

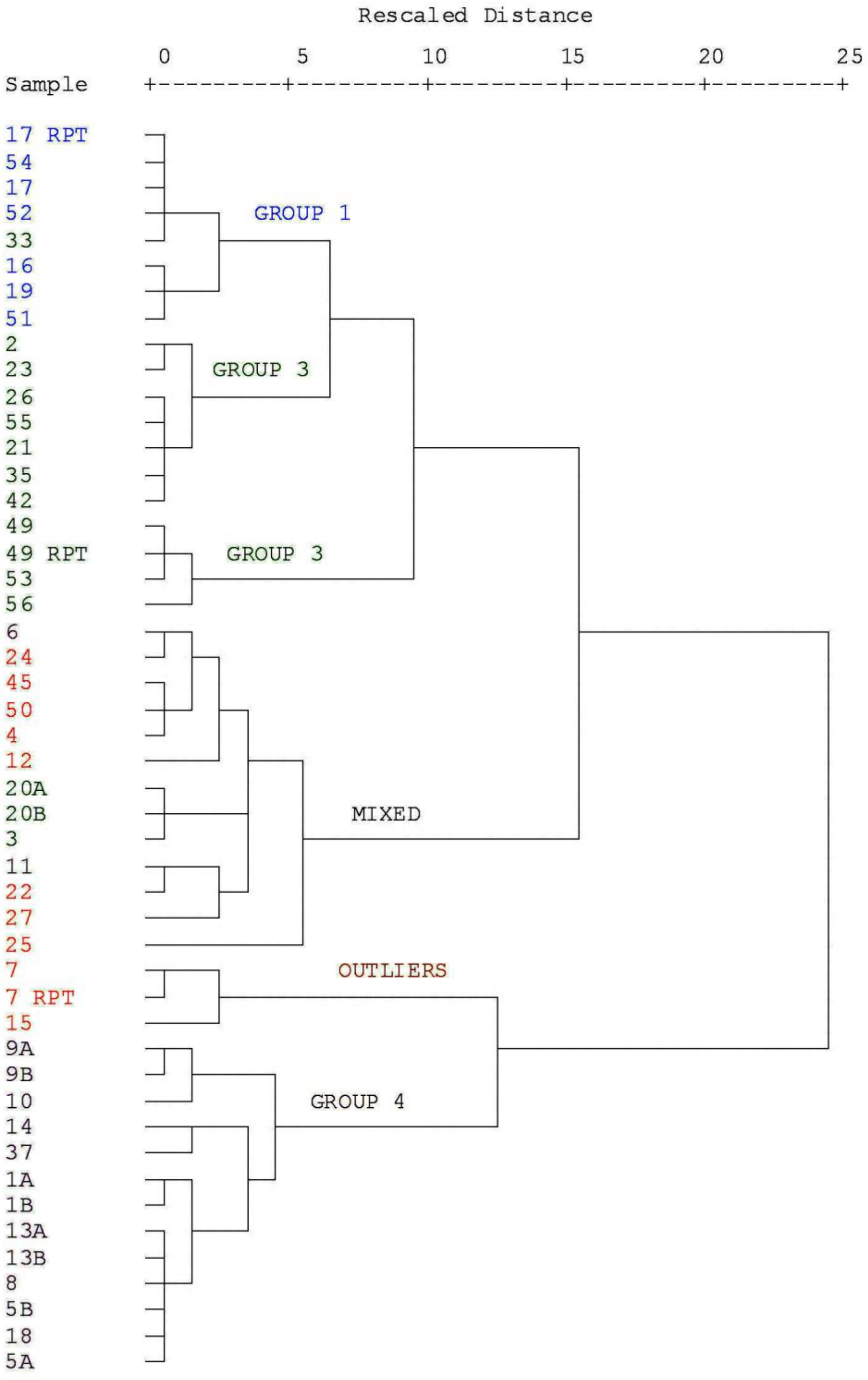
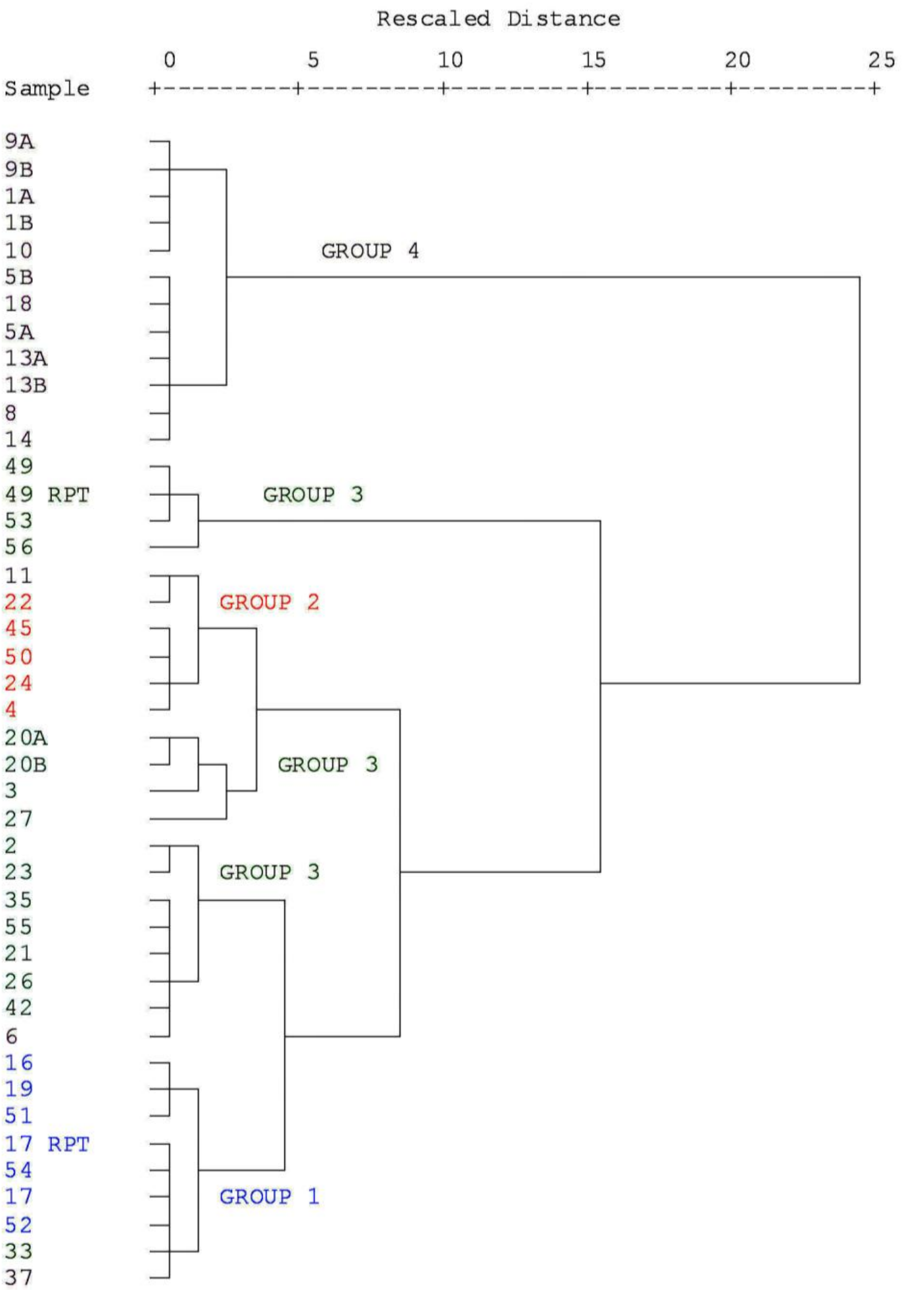


Fig. 5.37: HCA of MBA ICP data, select elements and samples




The chemical distinctiveness of the petrographic groups was further supported by DA. The first DA included all elements and samples, and proved fairly successful at assigning the samples to their designated petrographic group (Fig. 5.38). A second DA was run after removing problematic elements and outliers. The results revealed the same separate clusters, although the grouping was not as tight (Fig. 5.39). This is likely due to the removal of the outliers, as their chemical difference from the majority of the samples caused the clusters to appear in a tighter form. With these samples removed, the chemical differences between the groups were not as strong. While the DA provided excellent confirmation of the petrographic assignments, as well as illustrating the benefits of removing difficult elements and samples, the distinctiveness of the groups is to a certain extent created by the test itself. Therefore, a final cluster analysis was performed.

Fig. 5.38: DA of MBA ICP data, all elements and samples

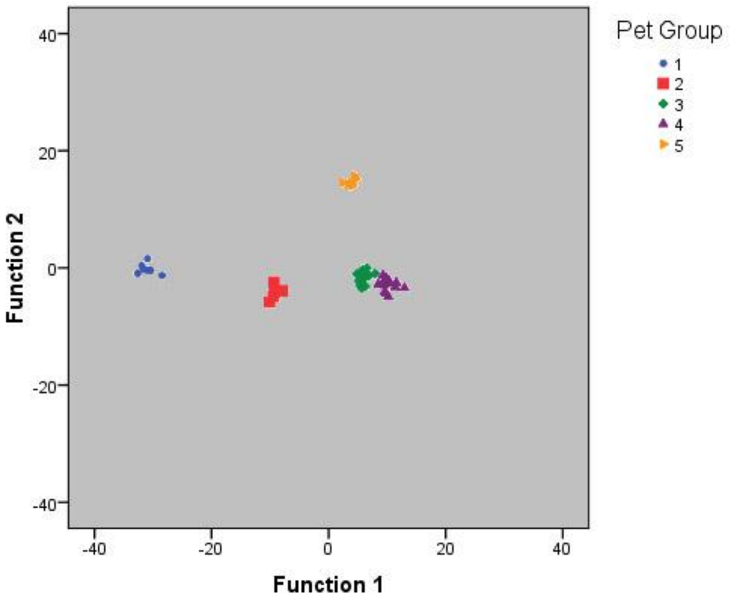
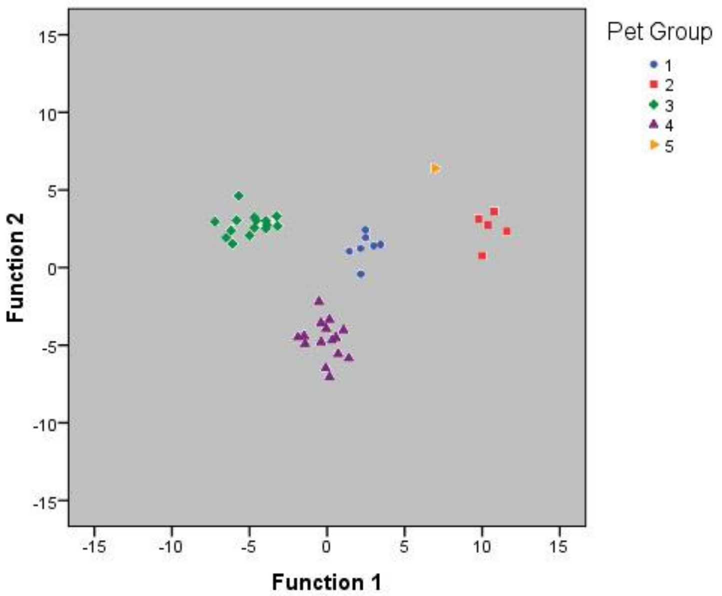



Fig. 5.39: DA of MBA ICP data, select elements and samples



KCA necessitates that the number of groups to be formed is specified (i.e. 5, 2, 3 etc.). For the first examination of the data, all samples were used and the analysis was set up to create five groups. This resulted in three clusters with most of the samples and two clusters dominated by outliers (Fig. 5.40). When a second KCA was run with only four groups designated and the outliers and problematic elements removed, the Group 4 samples were mostly placed in the first cluster (Fig. 5.41). However, the second cluster was heterogeneous, containing a mixture of samples from Groups 1, 2, and 3. Although the samples were petrographically identified as belonging to different groups, the KCA probably placed them together for the same reasons give above for the HCA. Additionally, since a majority of the samples are made of rendzina, the clay itself may show similar chemical signatures among samples that were produced in different locations.

Fig. 5.40: KCA of MBA ICP data, all elements and samples

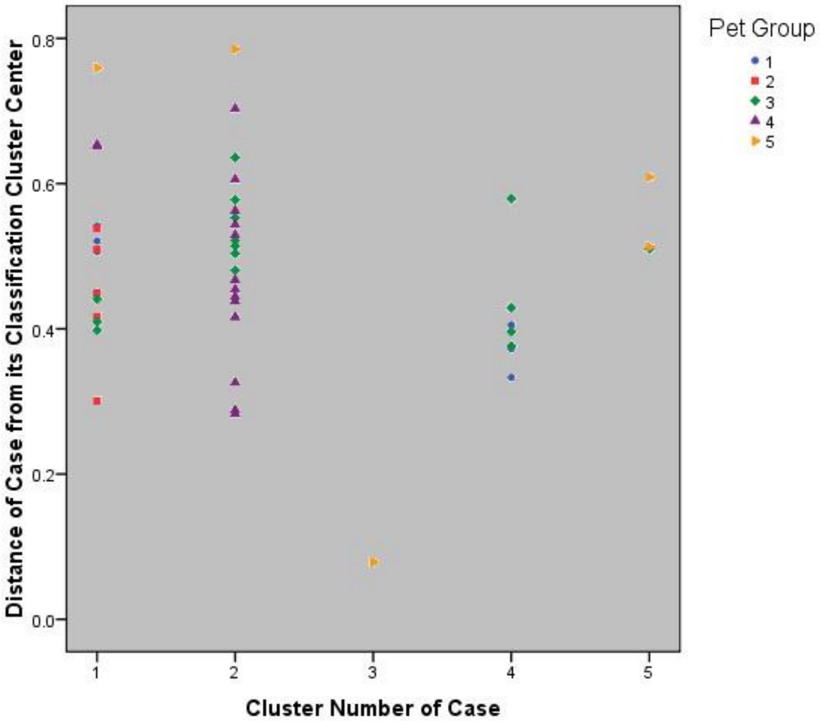
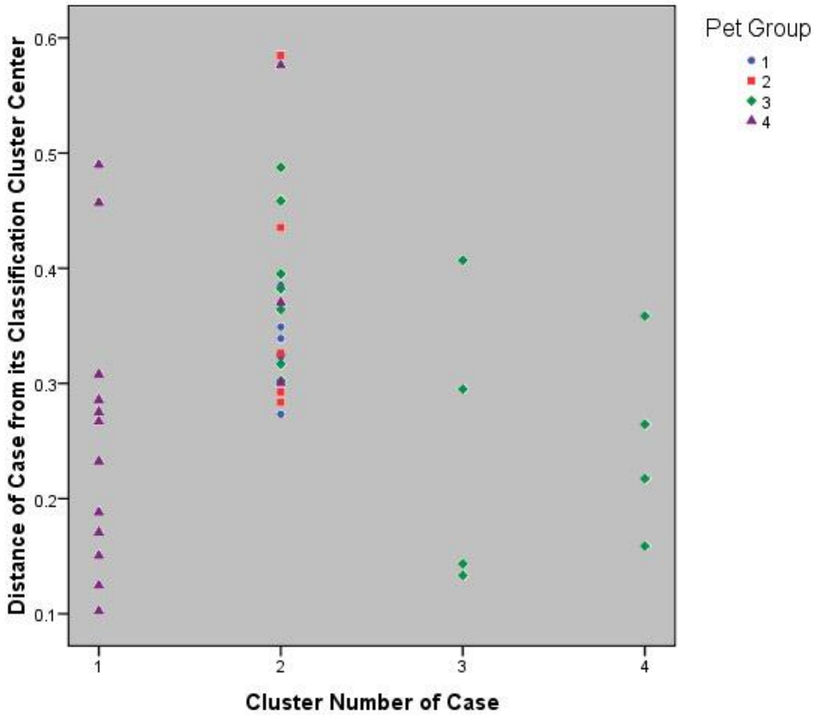


Fig. 5.41: KCA of MBA ICP data, select elements and samples




### 5.4.4 NAA data

An identical approach to the analyses of the ICP data was taken with the NAA data. The same four statistical tests were employed, each run once with all of the samples and elemental data, and then run a second time with certain elements and outliers removed. The first PCA revealed little grouping among the samples, with the first three PCs encompassing 75% of the variability (Fig. 5.42 and Table 5.7). The investigation of the precision of the NAA data had revealed that Cs, K, Mn, Rb, Ta, and Yb were problematic. The removal of elements was more important for the NAA because there were the same number of samples as determined elements. Ideally, statistical analyses should be run with more samples than elements (Baxter & Jackson 2001: 253-255; Baxter 2003: 126). Therefore, for the second PCA, it was advantageous to eliminate elements which reduced the statistical rigour of the analysis and to focus on important elements from the first PCA. Most of the elements that had contributed variability for the first PCA did likewise for the second (Table 5.8). The three PCs accounted for 83% of the variability; confirming that removing some elements and the outliers assisted in examining more of the variability in the data. However, the graph of the three PCs did not show any obvious patterns (Fig. 5.43).

Fig. 5.42: PCA of MBA NAA data, all elements and samples

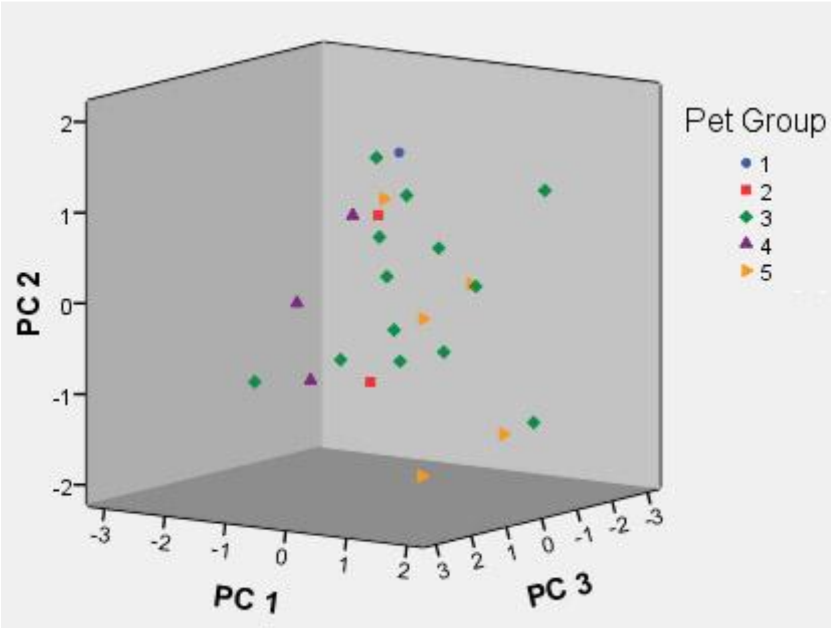



Table 5.7: Elements contributing variability to the first three components, MBA NAA data, all elements and samples

| PC 1 | PC 2 | PC 3 |
|---|---|---|
| Al, Ca, Ce, Co, Eu, Fe, La, Sc, Sm, Th, Ti, V | Cs, Hf, Mn, Rb, U, Yb | Na, Ti |

Fig. 5.43: PCA of MBA NAA data, select elements and samples

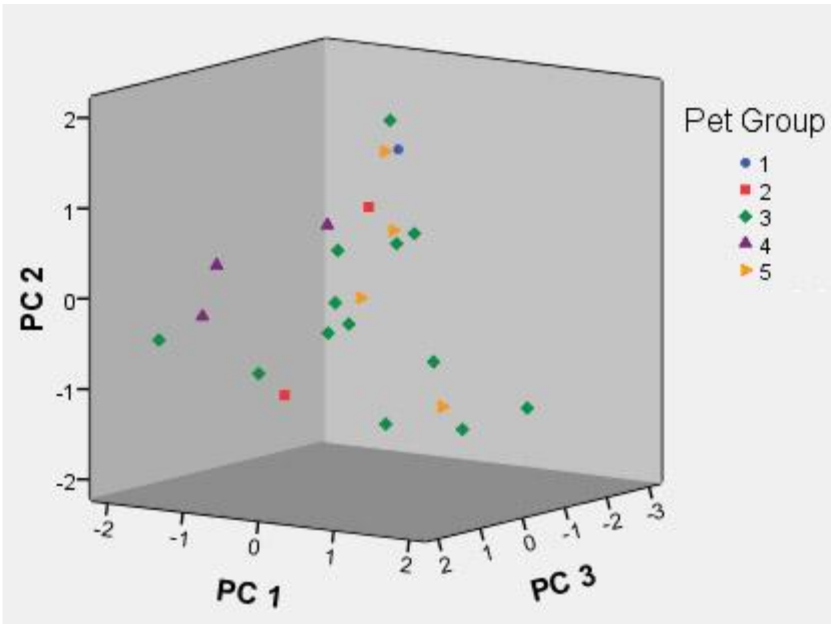


Table 5.8: Elements contributing variability to the first three components, MBA NAA data, select elements and samples

| PC 1 | PC 2 | PC 3 |
|---|---|---|
| Al, Ca, Ce, Co, Eu, Fe, La, Sc, Sm, Th, Ti, V | Cr, Dy, Eu, Na, U | Hf |

HCA was initially performed with all the samples and elemental data. Although this test also requires more samples than elements, the examination of all of the information without *a priori* assumptions was still a necessary first step. The results of the first HCA showed few interpretable groups based on the petrographic information, however, the samples with two analyses were generally placed near each other, suggesting that the data were of good quality (Fig. 5.44). The second HCA analysis, with the problematic elements and outliers removed, did not show much improvement (Fig. 5.45). Once again, this may be due to certain elements having comparable values between samples that are petrographically dissimilar. As most of the samples were produced from rendzina, this may have created issues in separating the samples chemically. The placement of the repeat analyses for sample Ownby 35 in two different clusters was a slight concern.

Fig. 5.44: HCA of MBA NAA data, all elements and samples

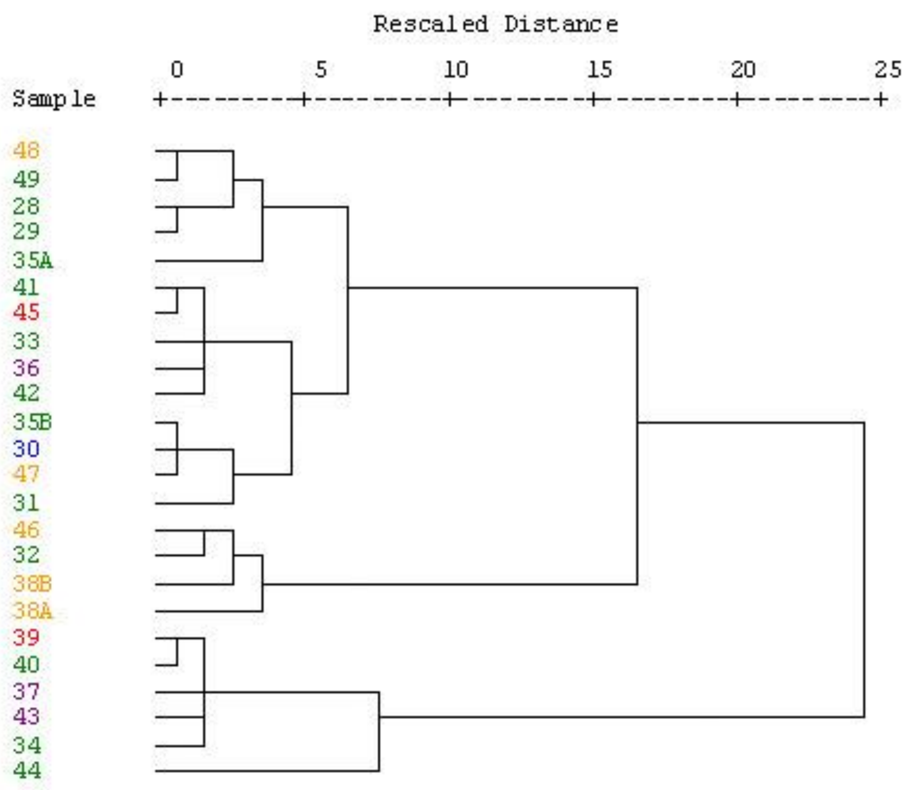
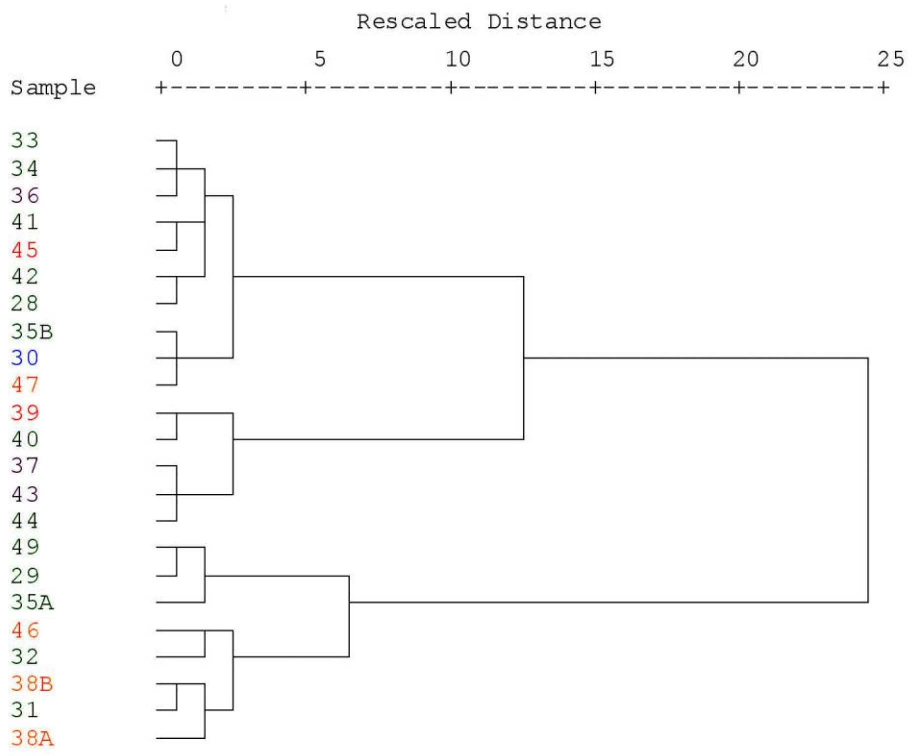


Fig. 5.45: HCA of MBA NAA data, select elements and samples




The DA proved more successful at separating the samples into their assigned petrographic groups. The first run with all of the elements and samples resulted in distinct clusters for groups 1, 2, and 4, while Group 3 was placed close to Group 5 (Fig. 5.46). When the second DA was performed, the results were improved with a better separation between Group 3 and Group 5 samples (Fig. 5.47). While these results are encouraging, this test maximizes the compositional differences between groups, giving a somewhat false impression that the samples are chemically very different from each other.

Fig. 5.46: DA of MBA NAA data, all elements and samples

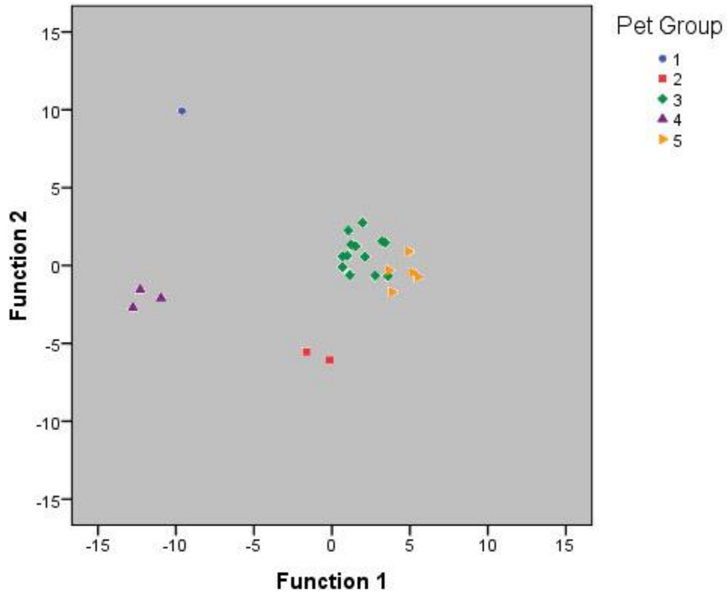
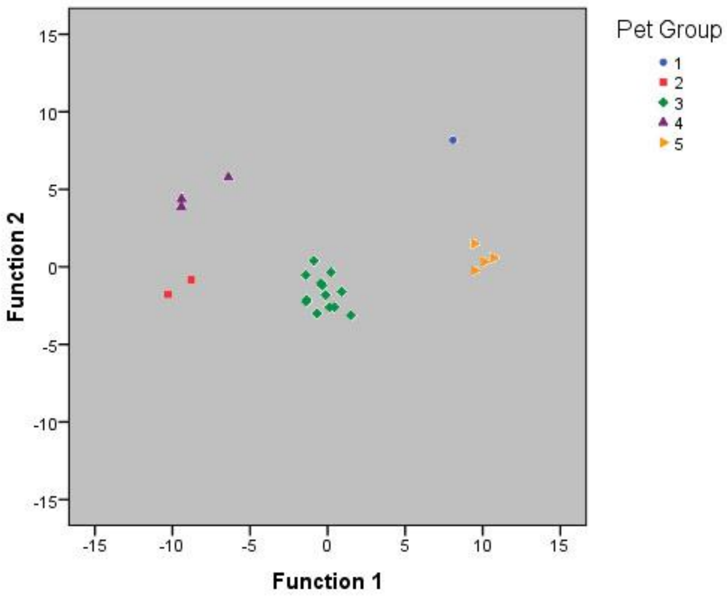



Fig. 5.47: DA of MBA NAA data, select elements and samples




The first KCA was run with all samples and elements, and five groups were created. The results showed that most of the samples were clustered into the first two groups, while the third group comprised Ownby 31, Ownby 32, and Ownby 38B. The second group consisted of Ownby 38A and Ownby 46, and the final group held only Ownby 44 (Fig. 5.48). The separation of analyses from the same samples suggested possible difficulties in the data. A second KCA run without the problematic elements and outliers, and with five groups specified, showed little improvement in clustering the samples by petrographic group (Fig.

5.49). The first group contained Ownby 32 and Ownby 46, while the third group consisted of Ownby 29, Ownby 35A, and Ownby 49. The fourth group comprised Ownby 38A and Ownby 38B. As KCA focuses on chemical similarities, it would appear that some of the determined elements had similar values in samples that were petrographically distinct.

Fig. 5.48: KCA of MBA NAA data, all elements and samples

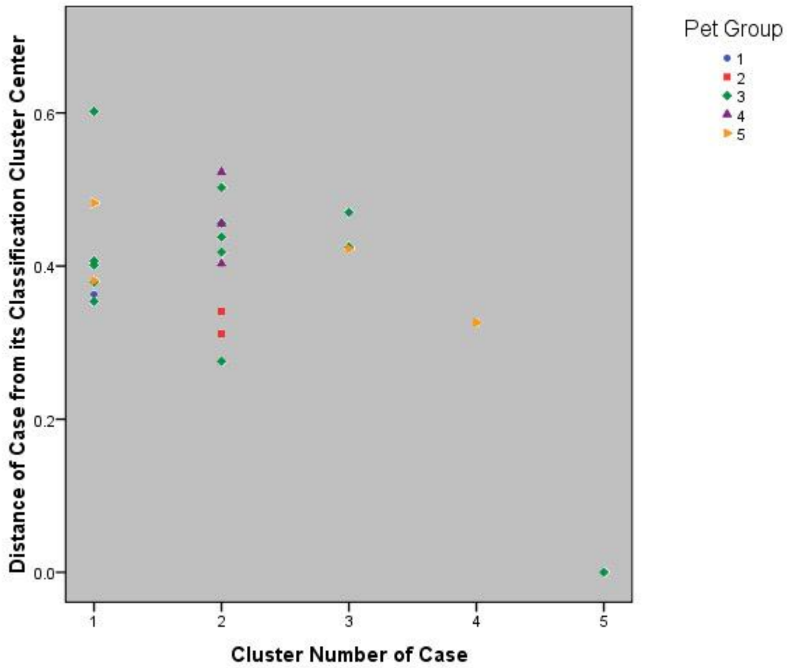
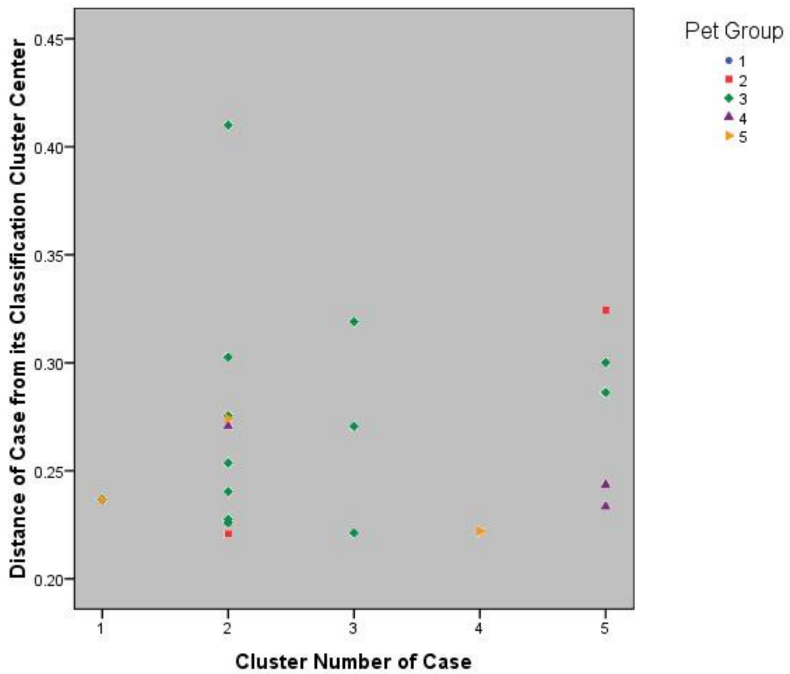



Fig. 5.49: KCA of MBA NAA data, select elements and samples



Overall, the results of the statistical analysis of the individual ICP and NAA data sets supported the petrographic assignments of the samples. Specifically, the DA provided good confirmation of the separation of the groups, although the other tests had results that were more equivocal. The ICP data in particular were effective in confirming similarities in samples believed to be produced in the same area and suggesting chemically distinct groups within the petrographic groups, i.e. samples Ownby 49, Ownby 53, and Ownby 56. Less success was achieved with the NAA data, possibly due to the fewer number of samples and the fact that those samples derived predominantly from a single petrographic group, Group 3. Additional problems may have been due to the processing of the data when it was acquired, information that was not provided by Al-Dayel (1995). Nevertheless, the combination of both compositional and petrographic data resulted in a clearer understanding of the variability within the samples.

## *5.5 Association of Petrographic Groups to Fabric Groups and Vessel Forms*

### 5.5.1 Association of petrographic and fabric groups

The selection of samples for petrographic analysis was based on the fabric classification of the MBA Canaanite jar sherds. Once the sherds had been placed into one of the five fabric groups (section 5.2.1), samples were taken that encompassed all of the variability in the fabrics. This was to ensure that the petrographic results would apply to the unsampled sherds within the fabric groups based on the similarities in appearance of the sherds at 20x magnification. However, when the fabric classification of the samples was examined, there was little correspondence between the fabric groups and the petrographic groups (Table 5.9 and Table 5.10). For example, while the samples assigned to petrographic Group 1 ("Akkar Plain") were only from fabric P103, other samples in this fabric group were placed in Group 3 ("Coastal Lebanon") and Group 5 (Outliers/"General Levant"). Other petrographic groups generally contained samples from more than one fabric group. Thus, Group 2 ("Inland Lebanon") held samples from P101, P104, and P105; Group 3 had samples from P100, P103, P104, and P105; and Group 4 ("Northern Coastal Palestine") contained samples from P100, P101, P102, and P105. The varied fabric designations for the samples in Group 5 were not surprising as this group contained those samples that could not be assigned to one of the four petrographic groups.

Table 5.9: Fabric groups within each petrographic group

| Petro. Group | Interpreted Provenance | Samples | Fabric Group* |
|---|---|---|---|
| 1 | Akkar Plain | 16, 17, 19, 30, 51, 52, 54 | **P103** |
| 2 | Inland Lebanon | 4, 22, 24, 39, 45, 50 | **P101** (39), **P104** (22, 24, 45, 50), **P105** (4) |
| 3 | Coastal Lebanon | 2, 3, 20, 21, 23, 26, 28, 29, 31, 32, 33, 34, 35, 40, 41, 42, 44, 49, 53, 55, 56 | **P100** (41, 42, 56), **P103** (26, 28, 29, 31, 32, 33, 34, 35, 40, 44, 49, 53, 55), **P104** (20, 21, 23), **P105** (2, 3) |
| 4 | N. Coastal Palestine | 1, 5, 6, 8, 9, 10, 11, 13, 14, 18, 36, 37, 43 | **P100** (36, 37, 43), **P101** (5, 6, 8, 13, 14, 18), **P102** (9, 10, 11), **P105** (1) |
| 5 (Outliers) | Varied or General Inland Levant | 7, 12, 15, 25, 27, 38, 46, 47, 48 | **P102** (12), **P103** (7, 27, 38, 46, 48), **P104** (15), **P105** (25, 47), |

*Number in parentheses is the Ownby sample number

Table 5.10: Petrographic groups within each fabric group

| Fabric Group | Samples | Petrographic Groups |
|---|---|---|
| P 100 | 36, 37, 41, 42, 43, 56 | 3, 4 |
| P 101 | 5, 6, 8, 13, 14, 18, 39 | 2, 4 |
| P 102 | 9, 10, 11, 12 | 4, 5 |
| P 103 | 7, 16, 17, 19, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 38, 40, 44, 46, 48, 49, 51, 52, 53, 54, 55 | 1, 3, 5 |
| P 104 | 15, 20, 21, 22, 23, 24, 45, 50 | 2, 3, 5 |
| P 105 | 1, 2, 3, 4, 25, 47 | 2, 3, 4, 5 |

The lack of association between the fabric groups and the petrographically defined groups was unexpected. Generally, the samples were characterized by either frequent well-sorted sand, frequent large limestone inclusions, black basalt fragments, or a fabric with little inclusions. In fact, these features did relate to interpreted provenance areas, with most samples dominated by well-sorted sand believed to derive from the coast of northern Palestine, samples with large limestone inclusions most likely coming from inland Lebanon, and samples with basalt fragments probably produced in the Akkar Plain. The samples that did not feature large quantities of either sand or limestone were often assigned to Coastal Lebanon. Thus, at a general level, P103 fabrics were designated as probably coming from either Coastal Lebanon or the Akkar Plain, P100 to P102 fabrics were normally assigned a production location on the northern coast of Palestine, and the P104 and P105 samples were usually placed in the interpreted provenance group from inland Lebanon. Samples without these characteristic features were mostly assigned to Group 5.

Overall, difficulties in successfully assigning a fabric group to an equivalent petrographic group seem to arise from two issues. First, many of the samples from the different proposed provenance areas were made with comparable clays, i.e. rendzina, that resulted in similar appearances. Second, within one postulated provenance region, the fabrics could show variable amounts of sand and limestone inclusions creating visually dissimilar fabrics that were probably produced in the same general area. This probably relates to the potters' use of unrefined materials with variable amounts of natural inclusions and inconsistencies in the amount of temper added. These tendencies were noted during thin section examination. Thus, the lack of direct and exclusive correspondence between the fabric group assignments and the petrographic group designations means that information from the unsampled sherds, classified only by fabric group, cannot be utilized to investigate further patterns of importation of MBA Canaanite jars to Memphis.

### 5.5.2 Association of petrographic groups and vessel forms

The difficulties in relating each petrographic group to a single fabric group also created problems when examining any connections between interpreted provenance area and vessel form. Since body sherds were sampled for the petrographic analysis, the connection between this material and the drawn rim, shoulder, handle, and base fragments (i.e. diagnostic sherds) was made through the fabric classification. Therefore, if a particular rim type was seen in a certain fabric, the petrographic analysis of a body sherd of the same fabric should indicate a likely area of production for the rim type. As a direct relationship between the fabrics and proposed provenance areas cannot be made, the likely area of manufacture for the drawn diagnostic sherd material cannot be established. However, six chips, which were not utilized for the thin section study, did derive from diagnostic rim sherds. Through macroscopic examination, the distinctive appearance of these chips could be related with a high degree of certainty to sherds from the petrographically defined groups (Fig. 5.50). This revealed that within production areas, the rims could be different, i.e. the two from "Inland Lebanon" and 23588 as compared to the others from "Northern Coastal Palestine". Alternatively, rims could appear similar, i.e. 23587 and 24349. However, the similarity between 21203 and 21247 from "Inland Lebanon" and "Coastal Lebanon" respectively, suggests that rims from different areas could also have an analogous shape. This argues for caution in making connections between rim shape and provenance areas without examination of the fabrics.  The remaining drawn rim fragments organized by fabric, which could not be assigned a possible provenance, are shown in Fig. 5.51, Fig. 5.52, Fig. 5.53, Fig. 5.54, Fig. 5.55, and Fig. 5.56[173].  These rims show some similarities to those linked to postulated provenances, but also highlight the variability of rim types for these jars.  Undoubtedly, both chronological differences and the presence of many workshops within and between production areas contribute to this impression.

Fig. 5.50: MBA Canaanite jar rims with interpreted provenance assignments

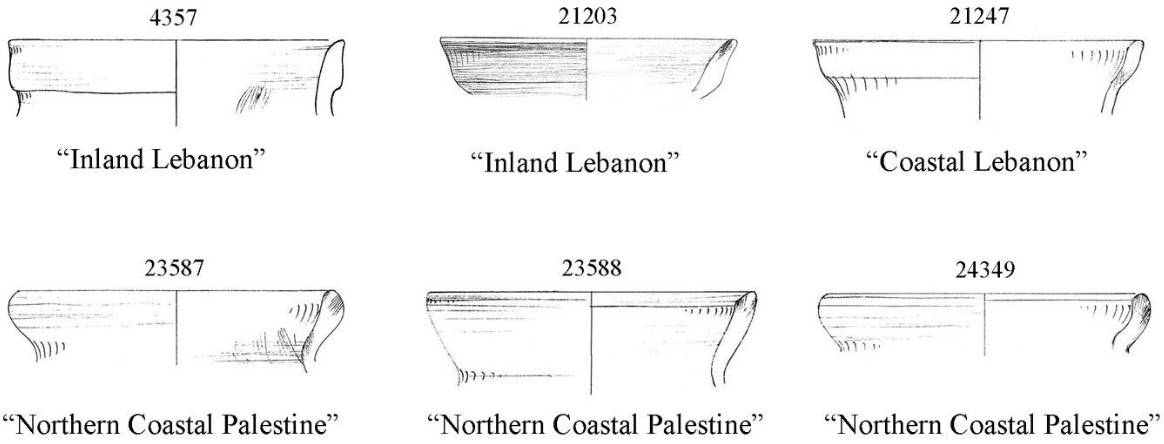



Fig. 5.51: MBA Canaanite jar rims of fabric P101

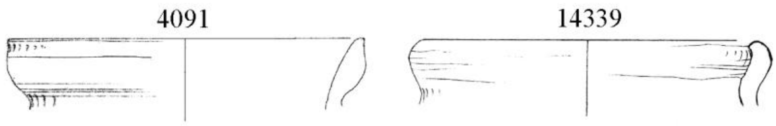
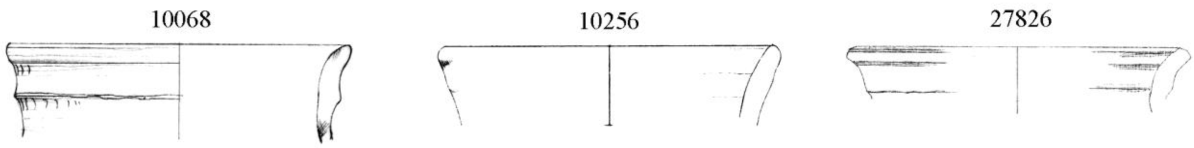



Fig. 5.52: MBA Canaanite jar rims of fabric P103




[173] As handles, bases, and sections of the body appear less diagnostic of different workshops, only the rim material has been reproduced here.

Fig. 5.53: MBA Canaanite jar rims of fabric P104

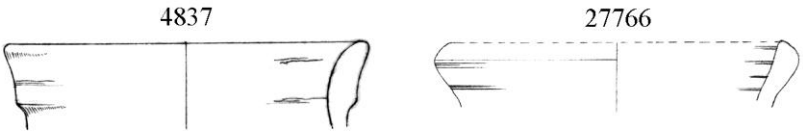



Fig. 5.54: MBA Canaanite jar rims of fabric P34

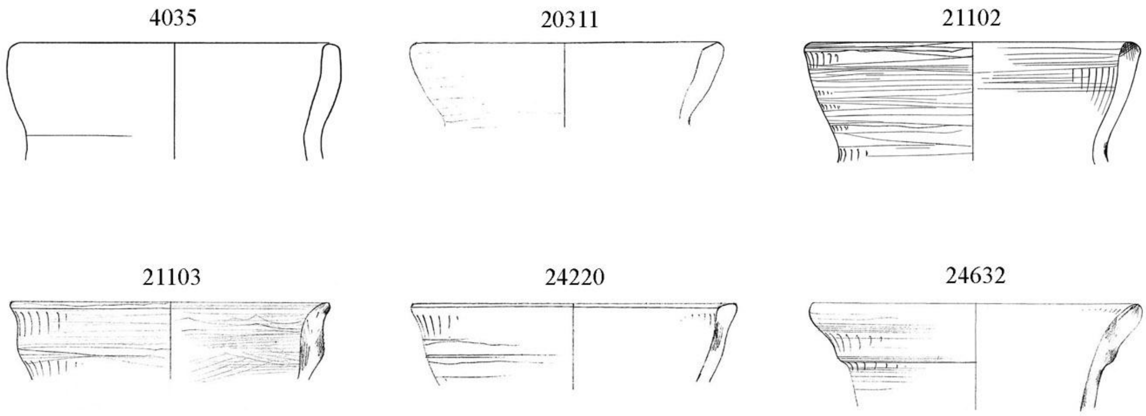



Fig. 5.55: MBA Canaanite jar rims of fabric P42

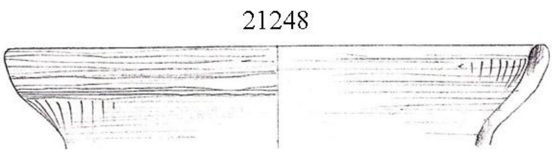
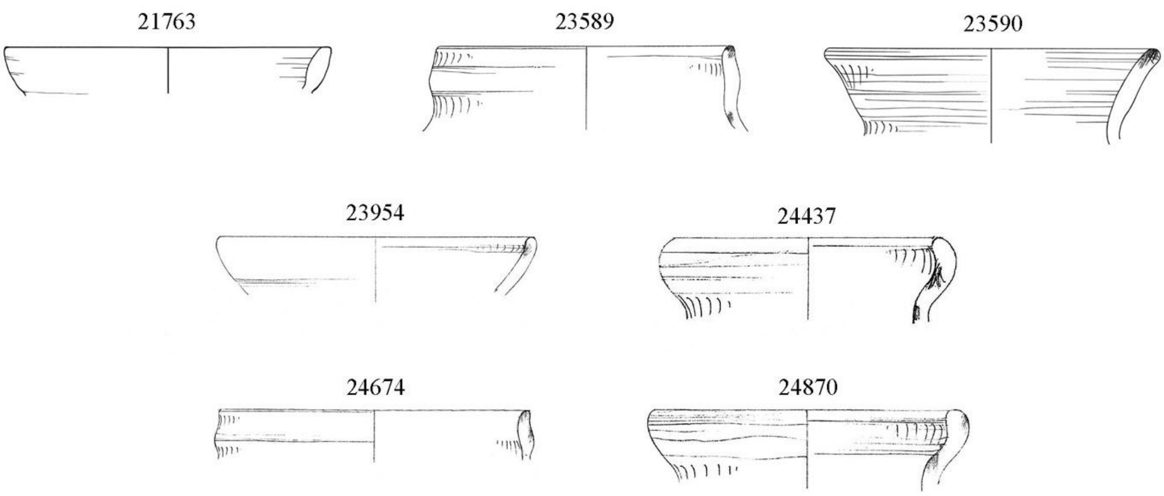



Fig. 5.56: MBA Canaanite jar rims of fabric P43



## *5.6 Conclusions*

The petrographic and chemical analyses of the 56 MBA Canaanite jar samples allowed the majority of these vessels to be assigned to four potential areas of production ranging from the Akkar Plain in northern Lebanon to the coast of northern Palestine. Petrographic investigation also revealed unique samples, and those that could only be assigned to the general Levant. At the same time, important information was acquired about the techniques of producing the vessels, showing that most were made from unrefined clays with some having coastal sand as a likely temper. The petrographic results were supported by the statistical analyses of the compositional data. Variability in the samples was notable and is probably due to chronological factors, slight differences in location of production within a region, and the methods of manufacture. The inconsistency of the samples caused difficulties when the petrographic group assignments were related to the fabric classifications of the samples. This unfortunately resulted in an inability to bring the material classified only by fabric into the current study through the relationship of fabric group and petrographic assignment. Additionally, correlations between vessel form and potential location of production could only be tentatively suggested for a few samples. Nevertheless, the results of the current study have shown that coastal areas in the central Levant were the primary producers of MBA Canaanite jars, with the majority of the analyzed samples deriving from Coastal Lebanon[174]. These conclusions support those made in the petrographic study of the imported ceramics at Tell el-Dab$^{c}$a (Cohen-Weinberger & Goren 2004), rather than the results of the NAA of imported material from the same site (McGovern 2000). The relationship between the Memphite MBA Canaanite jars and those from Tell el-Dab$^{c}$a are examined in the following chapter.

[174] Group 1 comprised seven samples, Group 2 six samples, Group 3 twenty-one samples, Group 4 thirteen samples, and Group 5 consisted of nine samples.

# Chapter 6: Comparison between Tell el-Dab$^{c}$a and Memphite MBA Canaanite jars

## *6.1 Introduction*

MBA Canaanite jars have been recovered from the earliest strata at $^{c}$Ezbet Rushdi through to the end of occupation at Tell el-Dab$^{c}$a, covering the period from the late 12$^{th}$ Dynasty to the end of the Second Intermediate Period (Bietak 1991b: passim.; Czerny 1999: 204; Fuscaldo 2000: 42-44, 87-90; Aston 2002: 44-45, 59-71; Aston 2004a: 163-164, 239-240; Hein & Jánosi 2004: passim.; Forstner- Müller 2008: passim.; Müller 2008: 185-187). The initial classification of the fabrics was made by M. Bietak (1991b: 328-330; Aston 2004a: 35). Expansion of this system was carried out by Kopetzky (2004: 254-255, 267, 274, 276), who noticed that there was a reduction over time in the number of fabrics along with the overall decline in imports (Aston 2004a: 239-240).

The NAA study by McGovern (2000) suggested that most of the imported vessels from Tell el-Dab$^{c}$a derived from southern Palestine[175]. However, there were problems in the methodology utilized by McGovern (considered in Chapter 1, c.f. Bourke 2002; Goren 2003; Aston 2004b). The subsequent petrographic study by Cohen-Weinberger & Goren (2004) provided evidence that the sampled Canaanite jars came from many areas in the Levant, from Syria to southern and inland Palestine. The published results and the existing thin sections provide a data set to compare with the MBA Canaanite jars from Memphis, in terms of the raw materials and suggested locations of production. Additionally, sherd material at Tell el-Dab$^{c}$a was also available for comparison. As the textual sources describing the political situation in Egypt at the time indicated that there was contact between the Eastern Delta and Memphis, similar material would be expected at both sites. However, the lack of Levantine objects other than Canaanite jars at Memphis, which were usually less than 1% of the total ceramic assemblage, suggested that limited interaction took place. The aim of this portion of the study was to carry out petrographic and macroscopic comparisons of MBA Canaanite jars from Tell el-Dab$^{c}$a and Memphis. Such a study would provide important evidence for clarifying contacts between the two sites.

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[175] The 274 jars analyzed by McGovern (2000) came from strata d/2 to a/2 and H to D/2 covering the late 12$^{th}$ Dynasty to the end of the 15$^{th}$ Dynasty (see Chapter 2, Fig. 2.8, page 24)

## 6.2 *Petrographic Comparisons*

### 6.2.1 Thin sections examined

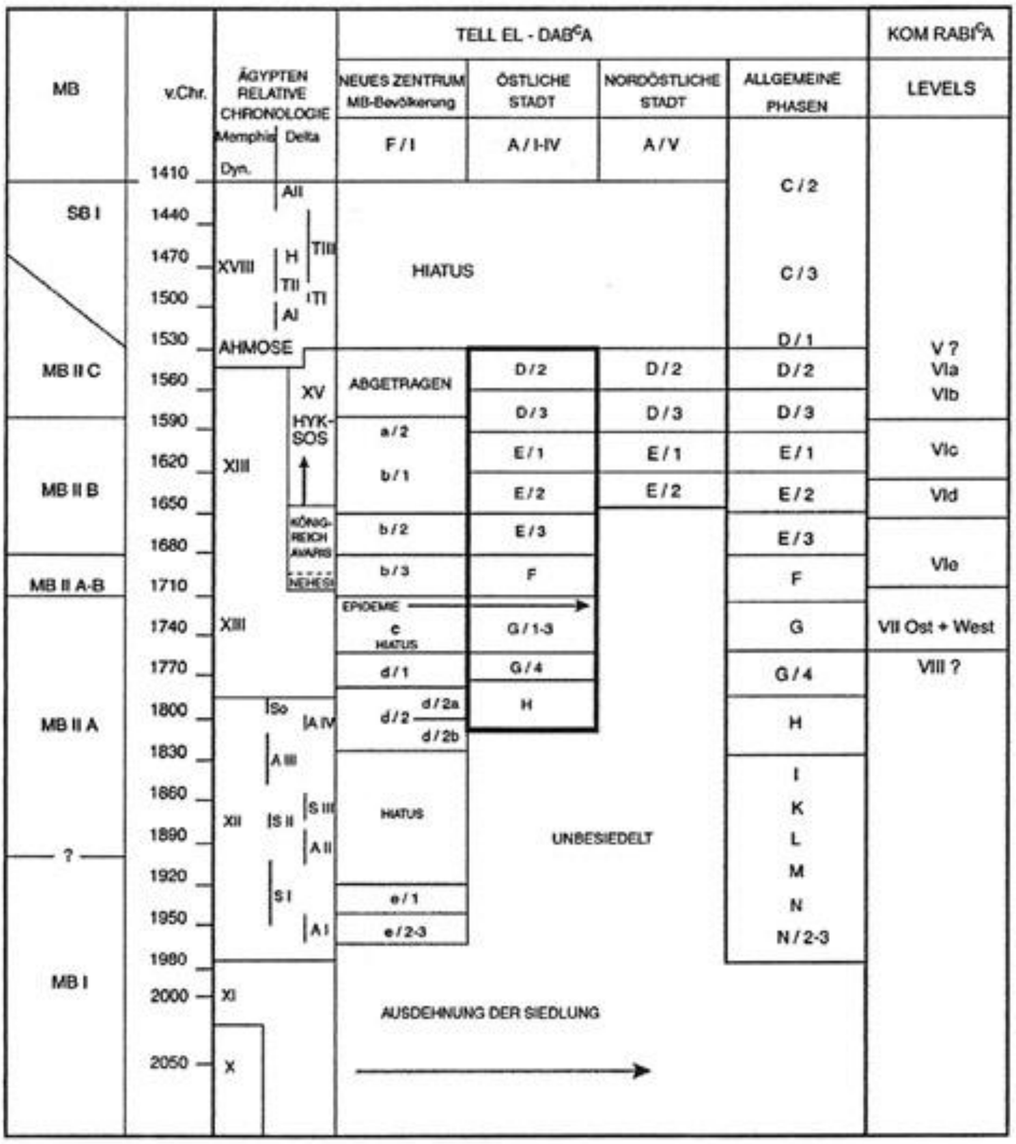
Thin sections of imported vessels excavated at Tell el-Dab$^{c}$a were examined at the Austrian Academy of Sciences in Vienna through the courtesy of M. Bietak and K. Kopetzky. A total of 231 thin sections were available for inspection, of which 217 were analyzed in the time allowed (Jan. 21$^{st}$ – Feb. 2$^{nd}$, 2008). The remaining 14 thin sections, of which 8 were from Canaanite jars, represented Tell el-Dab$^{c}$a ceramic fabrics (classified by K. Kopetzky) for which examples had already been examined. Out of the 217 inspected thin sections, 105 were from Canaanite jars[176] from strata b/2-d/2 in Area F/I and from strata E/3 to G/4 in Areas A/II, A/IV, and R/I ($^{c}$Ezbet Rushdi) (Table 6.1)[177]. The corresponding phases cover the period from the late 12$^{th}$ Dynasty to the late 13$^{th}$ Dynasty based on the Tell el-Dab$^{c}$a relative chronology (Fig. 6.1)[178]. The Memphis Canaanite jars were from levels VII to V, dated from the mid-13$^{th}$ Dynasty to the Second Intermediate Period based on the relative chronology at this site. Therefore, most of the Tell el-Dab$^{c}$a Canaanite jar thin sections available for examination were from vessels dated earlier than the samples from Memphis. This affects the comparability of the jars from the two sites.

Table 6.1: Number of Tell el-Dab$^{c}$a Canaanite jar thin sections examined by phase, based on list provided by K. Kopetzky

| Phase | Number of Samples | Relative Date[179] |
|---|---|---|
| E/3 | 2 | Late 13$^{th}$ Dynasty |
| E/3 – F | 8 | Late 13$^{th}$ Dynasty |
| F | 4 | 13$^{th}$ Dynasty |
| F – G/1-3 | 9 | 13$^{th}$ Dynasty |
| G/1-3 | 11 | 13$^{th}$ Dynasty |
| G/1-3 – G/4 | 38 | 13$^{th}$ Dynasty |
| G/4 | 3 | Early 13$^{th}$ Dynasty |
| H | 30 | Late 12$^{th}$ – Early 13$^{th}$ Dynasty |

[176] 70 samples were from a range of vessel types, while for 42 the vessel shape was not identified.
[177] See Fig. 2.7, page 21, for excavated areas at Tell el-Dab$^{c}$a.
[178] This figure illustrates the stratigraphic concordance established in the work by Bader (2009) from comparison of the ceramic material from Tell el-Dab$^{c}$a and Memphis.
[179] Relative Date is according to the Tell el-Dab$^{c}$a chronology, see Bietak 2002 and Fig. 2.8. The same applies to all subsequent tables with relative dates given in this chapter.

Fig. 6.1: Stratigraphic concordance between Tell el-Dab$^{c}$a and Memphis, Kom Rabi'a (Bader 2009: Fig. 397, based on Bietak 2002: Fig. 2)




Of the 217 Tell el-Dab$^{c}$a thin sections examined, only 43 were listed in the publication by Cohen-Weinberger & Goren (2004), in which they had been assigned to a petrographic group and region of production[180]. Of these, 36 thin sections derived from Canaanite jars while the remainder included jars, juglets, bowls, and a cooking pot (Table 6.2). The material ranged in date from the 13$^{th}$ Dynasty to the late 13$^{th}$ Dynasty. The examined Canaanite jar thin sections represented Cohen-Weinberger & Goren's (2004: 71-80) petrographic groups A2, B1, B2, B3, D, E, G, and K. However, thin sections were not

[180] The 300 thin sections analyzed by Cohen-Weinberger for her dissertation (written in Hebrew) and the publication were transported to New Zealand with her and were unavailable for examination. The majority of these samples were from Canaanite jars.

available for petrographic groups A1, C, F, H, and I, although thin section images were presented in the publication (Cohen-Weinberger & Goren 2004: Plate I)[181]. Nevertheless, many of the examined thin sections that were not a part of their study could be tentatively assigned to some of these groups. Table 6.3 provides a summary of their petrographic groups including vessel types and the relative date ranges of the strata in which the samples occurred. Fig. 6.2 illustrates the production areas assigned to each group based on the petrographic evidence.

Table 6.2: Tell el-Dab^c^a Canaanite jar thin sections (TS) examined with published petrographic group assignments by Cohen-Weinberger & Goren (2004). *=thin sections with inclusions, clay, or both comparable to Memphis samples

| TS # | Vessel # | Group | Location | Strata | Relative Date |
|---|---|---|---|---|---|
| 1 | K2409 | UC | Undetermined | b/3-2 | Late 13th Dynasty |
| 2* | K2409 | B2 | N. Palestine or Lebanon coast | b/3-2 | Late 13th Dynasty |
| 3* | K2409 | G | Central coast of Israel | b/3-2 | Late 13th Dynasty |
| 4* | K2409 | K | NW Negev/Shephelah | b/3-2 | Late 13th Dynasty |
| 5 | K2409 | K | NW Negev | b/3-2 | Late 13th Dynasty |
| 6* | K2409 | K | Shephelah | b/3-2 | Late 13th Dynasty |
| 8* | K2409 | K | NW Negev | b/3-2 | Late 13th Dynasty |
| 67* | K2817 | D | Lebanon | d/1 | Early 13th Dynasty |
| 69* | K2817 | K | NW Negev | d/1 | Early 13th Dynasty |
| 70 | K2817 | B3 | Northern Levant | d/1 | Early 13th Dynasty |
| 85 | K2817 | E | Akkar Plain | d/1 | Early 13th Dynasty |
| 86 | K2817 | D | Lebanon | d/1 | Early 13th Dynasty |
| 90 | K2817 | D | Lebanon | d/1 | Early 13th Dynasty |
| 91* | K2817 | B2 | N. Palestine or Lebanon coast | d/1 | Early 13th Dynasty |
| 93 | K2817 | D | Lebanon | d/1 | Early 13th Dynasty |
| 96 | K2817 | D | Lebanon | d/1 | Early 13th Dynasty |
| 97 | K2817 | D | Lebanon | d/1 | Early 13th Dynasty |
| 103 | K2817 | G | Central coast of Palestine | d/1 | Early 13th Dynasty |
| 104* | K2817 | B2 | N. Palestine or Lebanon coast | d/1 | Early 13th Dynasty |
| 105 | K2817 | G | Central coast of Palestine | d/1 | Early 13th Dynasty |
| 106* | K2817 | G | Central coast of Palestine /Menashe hills/Shephelah | d/1 | Early 13th Dynasty |
| 110* | K2817 | D | Lebanon | d/1 | Early 13th Dynasty |
| 111* | K2817 | D | Lebanon | d/1 | Early 13th Dynasty |
| 113* | K2817 | B1 | N. Lebanese coast | d/1 | Early 13th Dynasty |

181 Sherd breaks from samples assigned by the publication to petrographic groups H, I, and F were seen, see below.

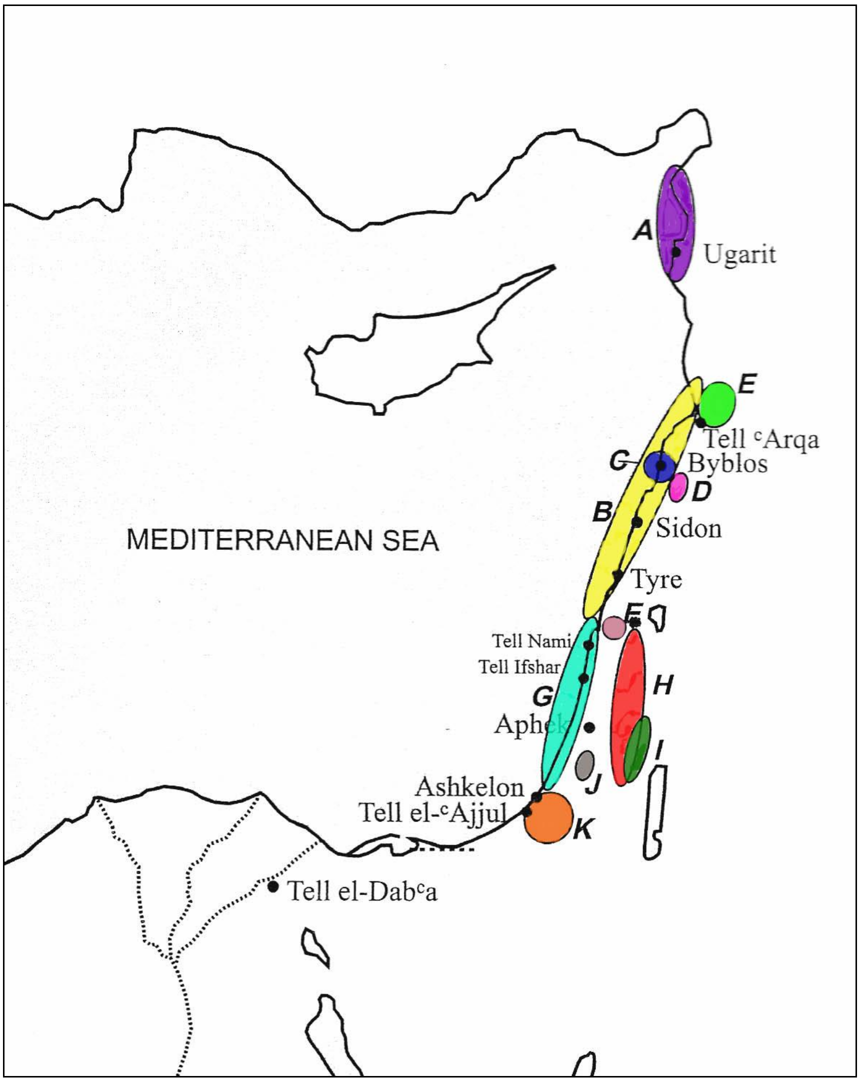
| TS # | Vessel # | Group | Location | Strata | Relative Date |
|---|---|---|---|---|---|
| 114* | K2817 | B2 | N. Palestine or Lebanon coast | d/1 | Early 13th Dynasty |
| 115* | K2817 | B2 | N. Palestine or Lebanon coast | d/1 | Early 13th Dynasty |
| 116* | K2817 | B2 | N. Palestine or Lebanon coast | d/1 | Early 13th Dynasty |
| 117 | K2817 | D | Lebanon | d/1 | Early 13th Dynasty |
| 118 | K2817 | A2 | Northwest Syria | d/1 | Early 13th Dynasty |
| 119 | K2817 | D | Lebanon | d/1 | Early 13th Dynasty |
| 120* | K2817 | UC | Undetermined | d/1 | Early 13th Dynasty |
| 121 | K2817 | D | Lebanon | d/1 | Early 13th Dynasty |
| 128* | K2817 | UC | Undetermined | d/1 | Early 13th Dynasty |
| 131 | K2817 | UC | Undetermined | d/1 | Early 13th Dynasty |
| 164* | K5570 | B3 | Northern Levant; wall frag. | E/3 | Late 13th Dynasty |
| 172 | K5570 | UC | Undetermined | E/3 | Late 13th Dynasty |

Table 6.3: Summary of petrographic groups from Cohen-Weinberger & Goren (2004). *=thin section seen by author, **=only a sherd sample seen by author

| Group | Clay and Major Inclusions | Location | Vessel Types | Relative Dates |
|---|---|---|---|---|
| A1 | micaceous and serpentine-rich clay; limestone, radiolarian chert, serpentine, and volcanic and schistous rock fragments | NW Syria: Ugarit, Amuq area, or the Cilician coast | Cjar, handless jar, jug/jar, juglet | Late 12th – 15th Dynasty |
| A2* | Same as above but lacking radiolarian chert | NW Syria: Ugarit, Amuq area, Cilician coast, or Cyprus | Cjar, jug, juglet | 12th – 15th Dynasty |
| B1* | Rendzina, marl or alluvial clay (can be mixed with *Terra Rossa*); limestone, chalk, bioclasts (*Amphiroa* sp. algae), beachrock, chert, chalcedony, geode quartz, and volcanic rock fragments | Northern Lebanese or Syrian Coast | Cjar, jug, jug/jar, juglet | Late 12th – 15th Dynasty |
| B2* | Same as above but lacking volcanic rock fragments | N. Palestinian coast or Lebanese coast | Cjar, jug, jug/jar, juglet, bowl, platter | Late 12th – 15th Dynasty |
| B3* | Same as B2 but lacking *Amphiroa* sp. algae | Northern Levant | Cjar, jug, jug/jar, juglet, bowl | 12th – 15th Dynasty |
| C | Calcareous clay; limestone, chalk, marly shale, opaque | Byblos, Lebanese | Cjar | 13th Dynasty |

| Group | Clay and Major Inclusions | Location | Vessel Types | Relative Dates |
|---|---|---|---|---|
| | hematite particles, foraminifera, calcite, quartz, and chert | Coast | | |
| D* | Carbonatic or ferruginous clay; quartz, sandstone, various types of limestone, iron oxide ooliths, and shale | Lebanon | Cjar, jug, juglet, bowl, lamp | Late 12th – 15th Dynasty |
| E* | Rendzina or marl clay; limestone, chalk, foraminifera, calcite, quartz, chert, mollusk shells, and basalt rock fragments | E. Galilee or Jezreel Valley or Yarmuq area or Akkar Plain or Middle Orontes N. of Qadesh | Cjar, jug/jar, cooking pot | 12th – 15th Dynasty |
| F** | Rendzina; limestone, travertine, quartz, and volcanic tuff inclusions | Mount Carmel | Cjar, juglet, bowl, cooking pot, tankard | 12th – 15th Dynasty |
| G* | *Hamra*; quartz, kurkar, limestone, and feldspars | Central coast of Palestine | Cjar, bowl | Late 12th – 15th Dynasty |
| H** | *Terra Rossa*; quartz, limestone, chert, and sometimes organic matter | Judea, Samaria, or Galilee mountains | Cjar | Late 13th – 15th Dynasty |
| I** | Dolomitic clay; dolomite, limestone, chalk, quartz, and chert | Judea or Samaria hills | Cjar | Late 13th – 15th Dynasty |
| J* | Calcareous clay; foraminifera, quartz, and rarely chert or crushed calcite | Shephela/ Wadi I^c^ron | juglet, cooking pot | 15th Dynasty |
| K* | Loess; quartz, limestone, chalk, kurkar, and feldspars | NW Negev/ Shephelah | Cjar, jug, juglet, bowl | 12th – 15th Dynasty |

Fig. 6.2: Map of provenances for petrographic groups A-K (Cohen-Weinberger & Goren 2004: Fig. 1)




The study by Cohen-Weinberger & Goren (2004) revealed that some fabrics were more common than others; some were employed for certain vessel types only; and some were common only in a particular period. Group A fabrics were utilized for Canaanite jars and other vessels, but were rare throughout all strata. Group B fabrics were used for Canaanite jars and many other vessel types, and were the most common in all strata. Only a few Canaanite jars were manufactured in a Group C fabric and appeared in the 13$^{th}$ Dynasty strata. Fabrics in Group D were utilized for Canaanite jars and other vessels, while being relatively rare except in the 13$^{th}$ Dynasty. Cooking pots, jugs/jars, and Canaanite jars were manufactured in Group E fabrics and were uncommon in the strata. Vessels in Group F fabrics included Canaanite jars, bowls and cooking pots, and were found in low numbers throughout the strata. Likewise, Group G fabrics were rare in the strata and comprised Canaanite jars and bowls. Groups H and I fabrics were used exclusively for a few Canaanite jars in late 13th and 15th Dynasty strata. The only fabric not utilized for Canaanite jars was Group J, represented by a juglet and cooking pot from a 15th Dynasty stratum. Finally, Group K fabrics were employed for many vessel types including Canaanite jars and were fairly common in the 13th and late 13th Dynasty. This summary provides the necessary background to assess which fabrics, based on the published material, were likely to be similar to those from Memphis, given their production location, prevalence and utilization for Canaanite jars.

### 6.2.2 Results

Examination of the thin sections in Vienna initially focussed on the 43 samples discussed by Cohen-Weinberger & Goren (2004) because their provenance had been reasonably established. This assisted in identifying minerals and clay types that were similar to the Memphite samples. Further, those thin sections not examined by Cohen-Weinberger & Goren (2004) could be viewed in a more informative way when inclusions and clays similar to the published thin sections were seen. Comparison between the 105 Tell el-Dab^c^a Canaanite jar thin sections (including those analyzed by Cohen-Weinberger & Goren) and the Memphite Canaanite jar samples resulted in the identification of 61 similar examples (including 19 of the 36 published examples), with the remaining 44 appearing different between the two corpora.

Often the inclusion types were similar among samples from the two sites, but the clay was different. This is not surprising as Levantine potters had a variety of clays available to them, and the analyses by Cohen-Weinberger & Goren (2004) had shown the use of different clays with the same set of inclusions (noted for Groups B, D, and E). Conversely, for some comparisons, the clay type was analogous but the inclusions were not. This is due to the wide distribution of certain clay types along the Levantine coast that can be combined with a variety of mineral inclusions, sometimes deliberately added as temper. Very rarely were the thin sections a close match, but this was expected given the variability in both clays and inclusion material.

The sections that appeared similar to the Memphite examples derived predominantly from the Coast of Lebanon (Memphis Group 3, Tell el-Dab^c^a Groups B1-B2), with a few from the northern Coast of Palestine (Memphis Group 4, Tell el-Dab^c^a Group G) (Table 6.3

and Fig. 6.3, Fig. 6.4, and Fig. 6.5)[182]. A smaller number of similar thin sections were seen from samples of Tell el-Dab$^{c}$a Groups D (comparable to Memphis Group 2) and K (slightly comparable to Ownby 48) from Lebanon and NW Negev/Shephelah respectively (Fig. 6.6 and Fig. 6.7). For Memphis Group 2, a few thin sections from Tell el-Dab$^{c}$a Group B3 samples appeared generally similar (Fig. 6.8). Comparison of the one thin section from Group E (assigned to the Akkar Plain) examined by Cohen-Weinberger & Goren (2004: 76) to the Memphis samples assigned to this area did not reveal any similarities, but two unpublished samples with basalt inclusions were comparable (Fig. 6.9). Overall, the Tell el-Dab$^{c}$a samples that were similar to the Memphite examples derived from areas along the coast of Palestine and Lebanon; the same region independently suggested as the location of production for the Memphite jars.

[182] The colour of the clay and inclusions in images taken from thin sections will be affected by the resin used, the light source of the microscope, and the camera. Images taken under different conditions may appear dissimilar even if the thin sections under the microscope appear similar. For the figures illustrating the comparison between the Tell el-Dab$^{c}$a and Memphis jars, examples with similar inclusions were selected as this is more indicative of provenance.

Fig. 6.3: Comparison of chip and thin section images (PPL and XPL), Tell el-Dab[c]a TS# 113 (Group B1) and Ownby 23 (Group 3)

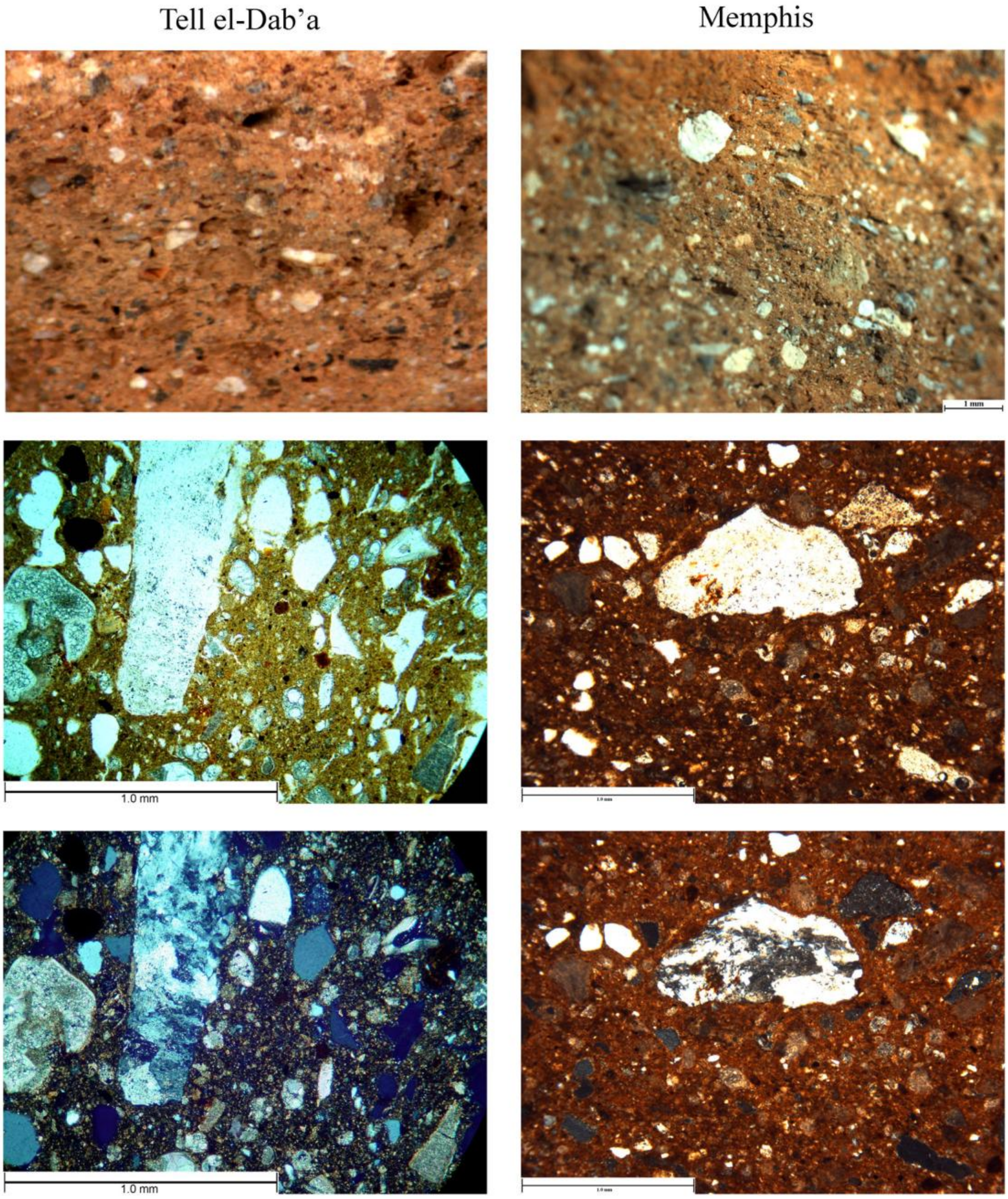


Fig. 6.4: Comparison of chip and thin section images (PPL and XPL), Tell el-Dab$^{c}$a TS# 104 (Group B2) and Ownby 49 (Group 3)

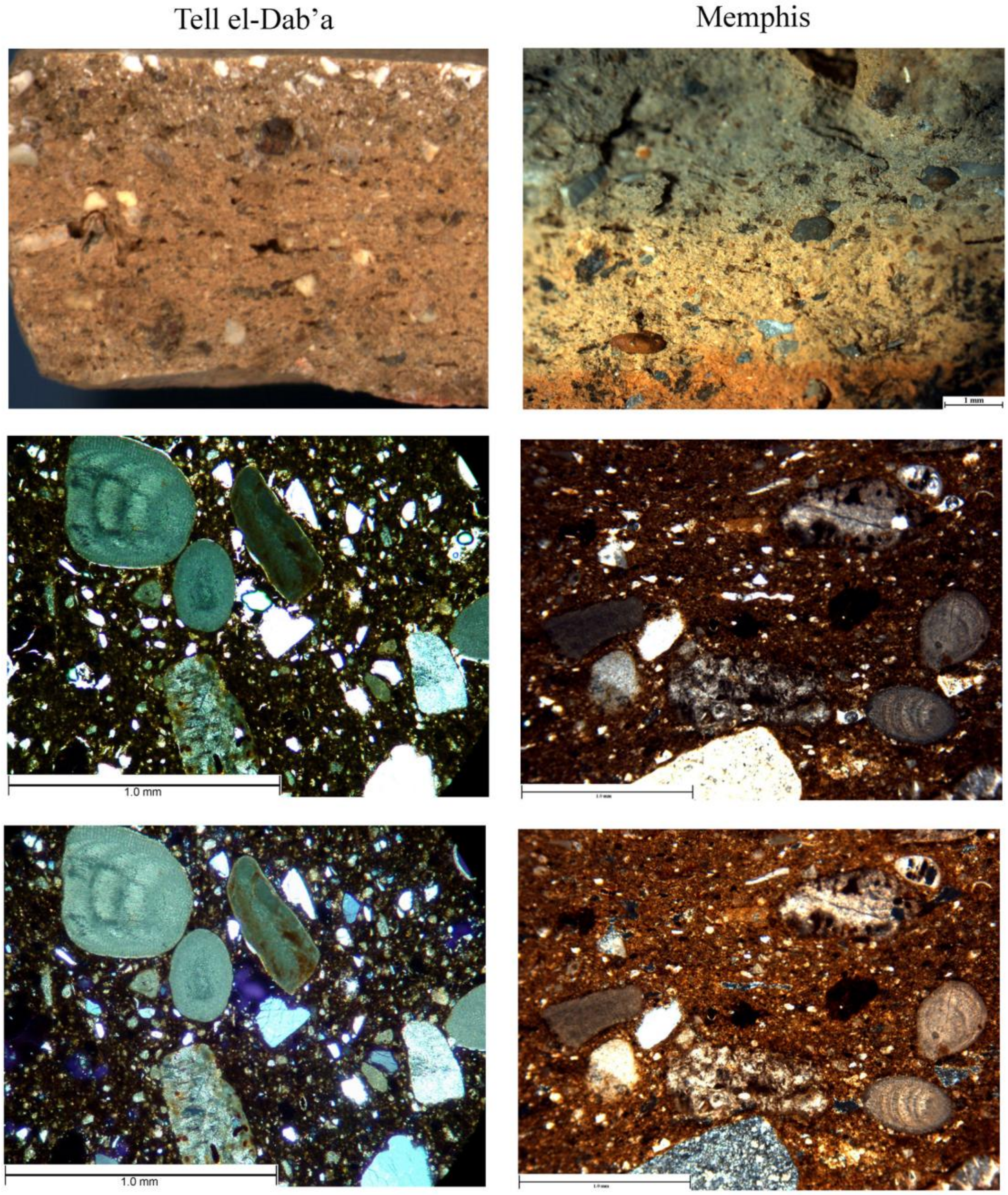


Fig. 6.5: Comparison of chip and thin section images (PPL and XPL), Tell el-Dab$^{c}$a TS# 3 (Group G) and Ownby 14 (Group 4)

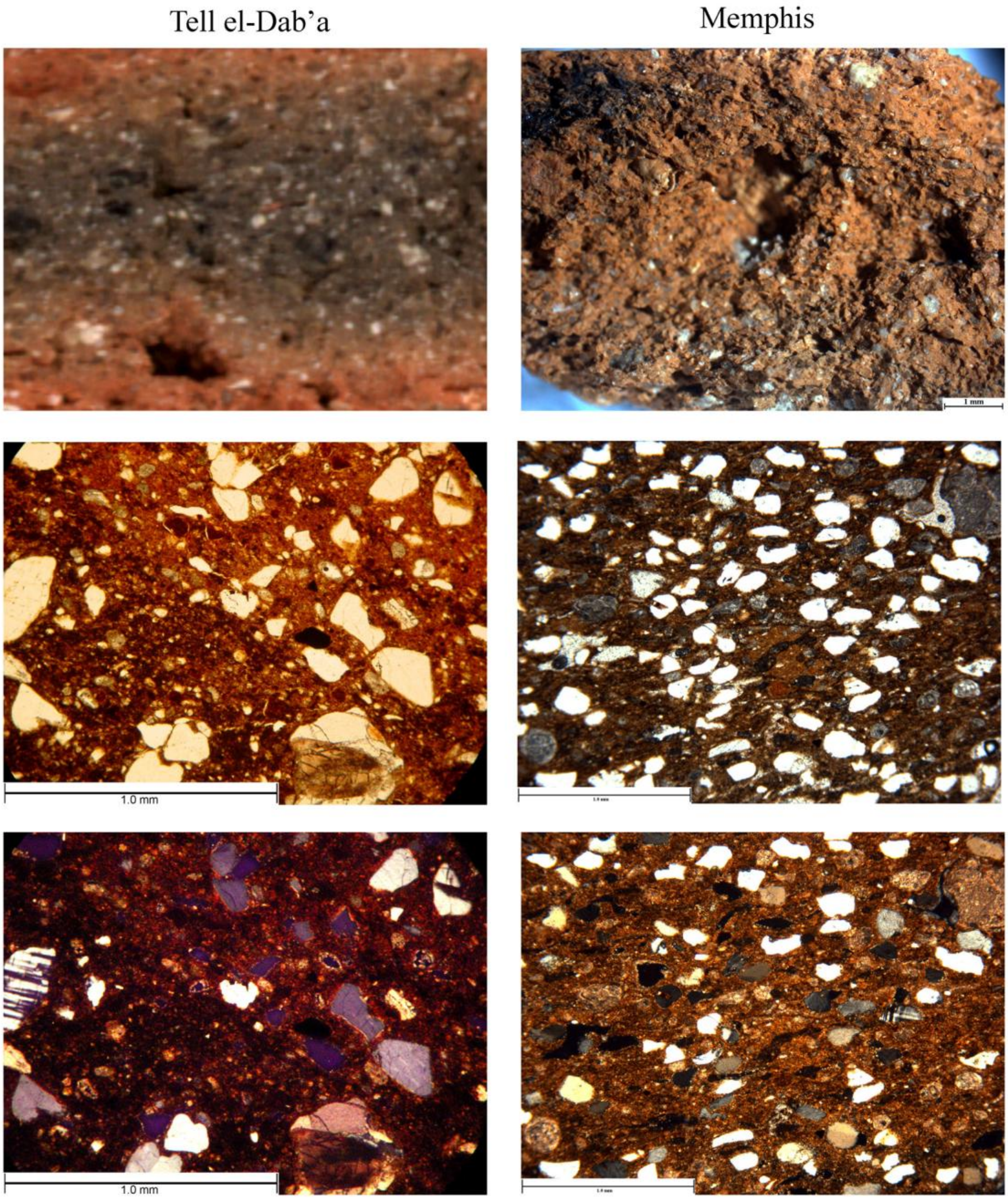


Fig. 6.6: Comparison of chip and thin section images (PPL and XPL), Tell el-Dab$^{c}$a TS# 67 (Group D) and Ownby 22 (Group 2)

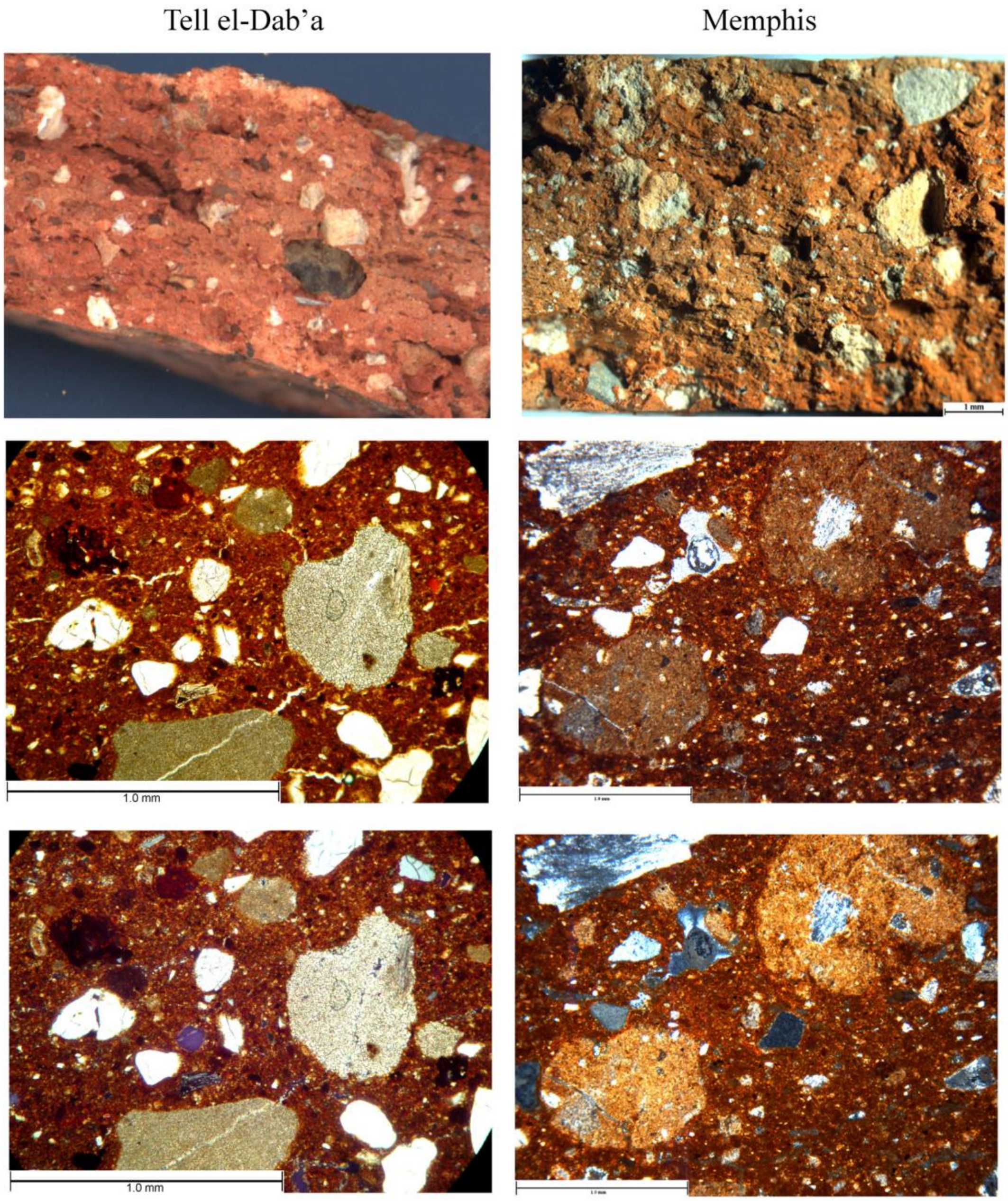


Fig. 6.7: Comparison of chip and thin section images (PPL and XPL), Tell el-Dab$^{c}$a TS# 6 (Group K) and Ownby 48

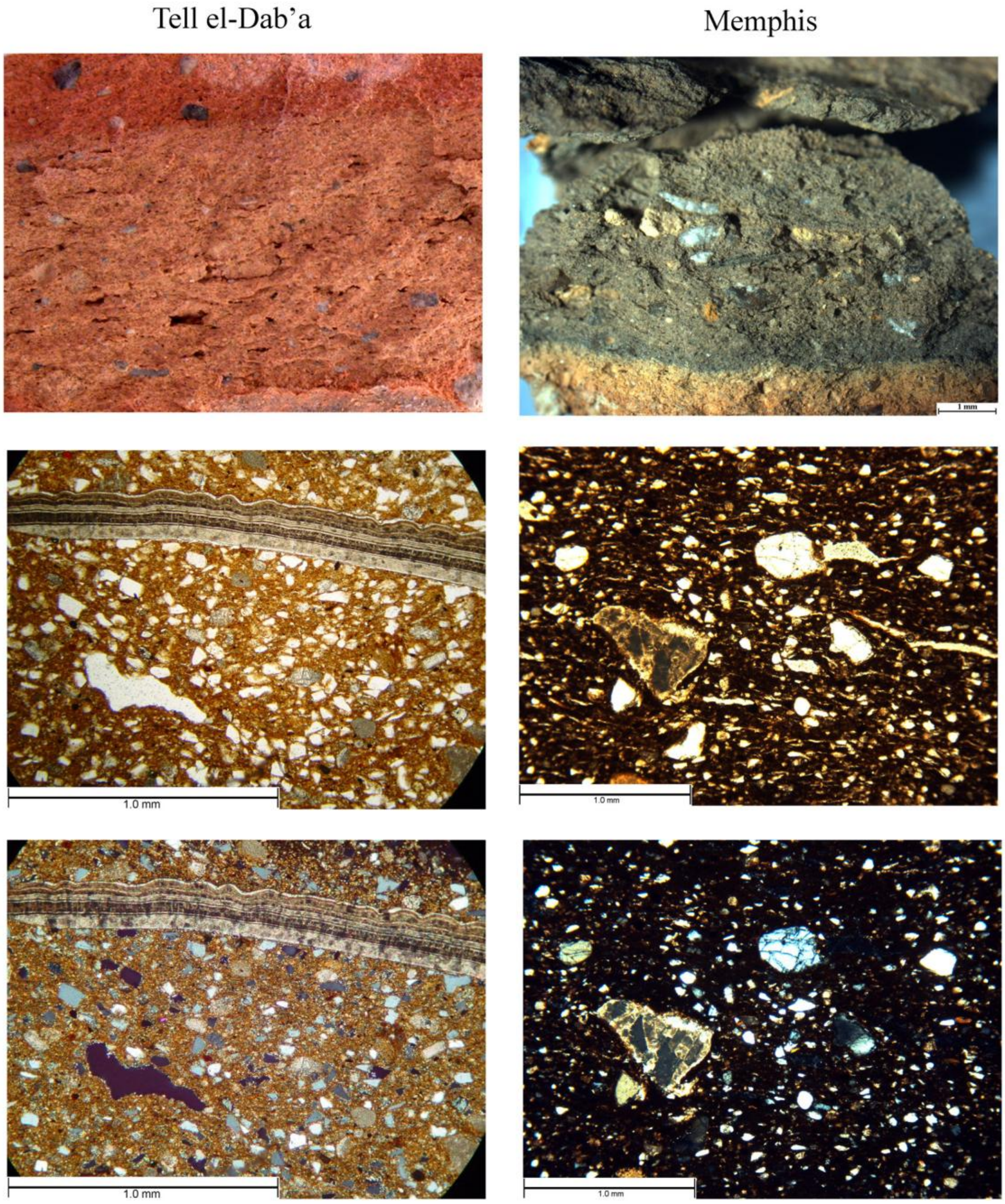


Fig. 6.8: Comparison of chip and thin section images (PPL and XPL), Tell el-Dab$^{c}$a TS# 164 (Group B3) and Ownby 45 (Group 2)

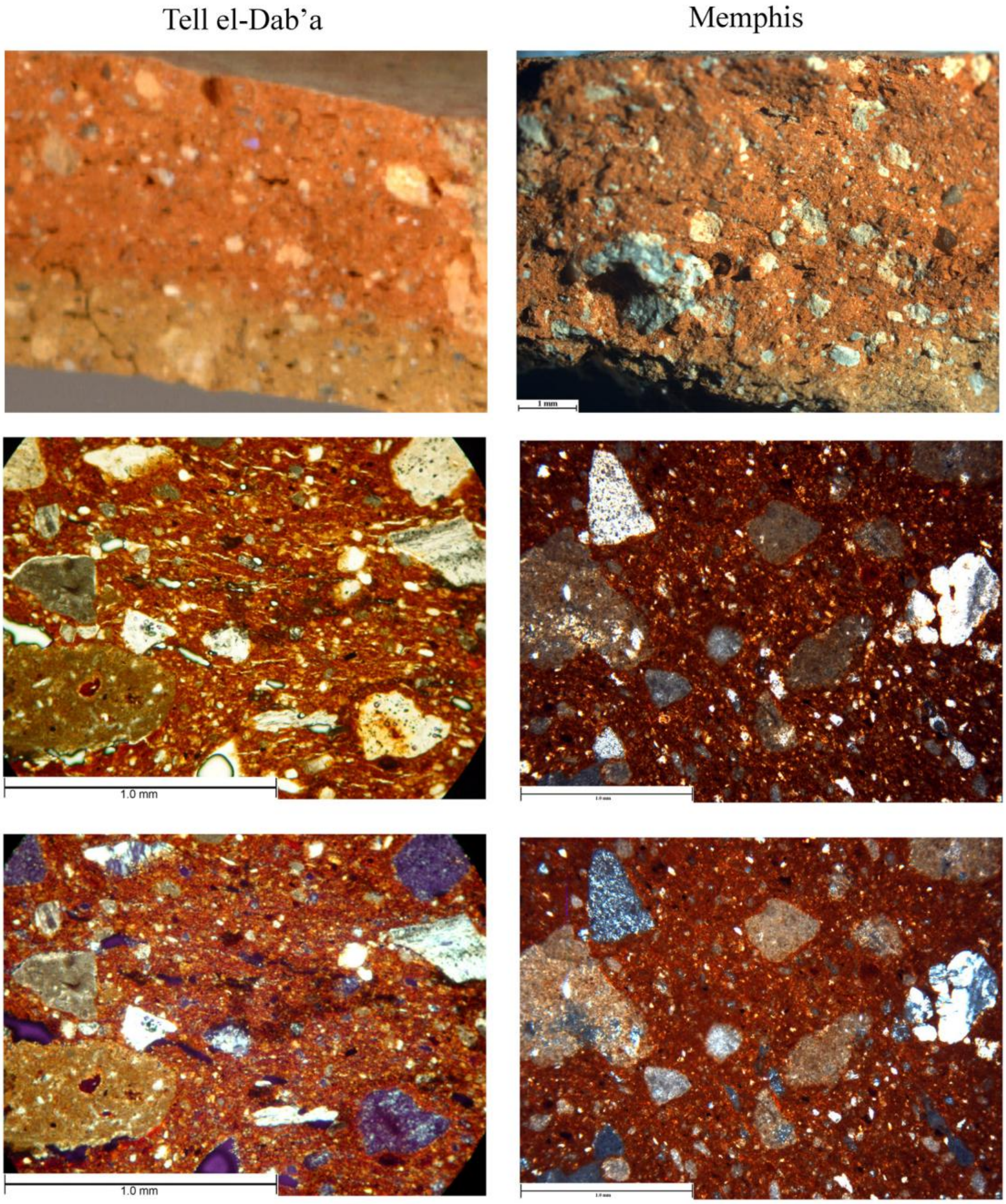
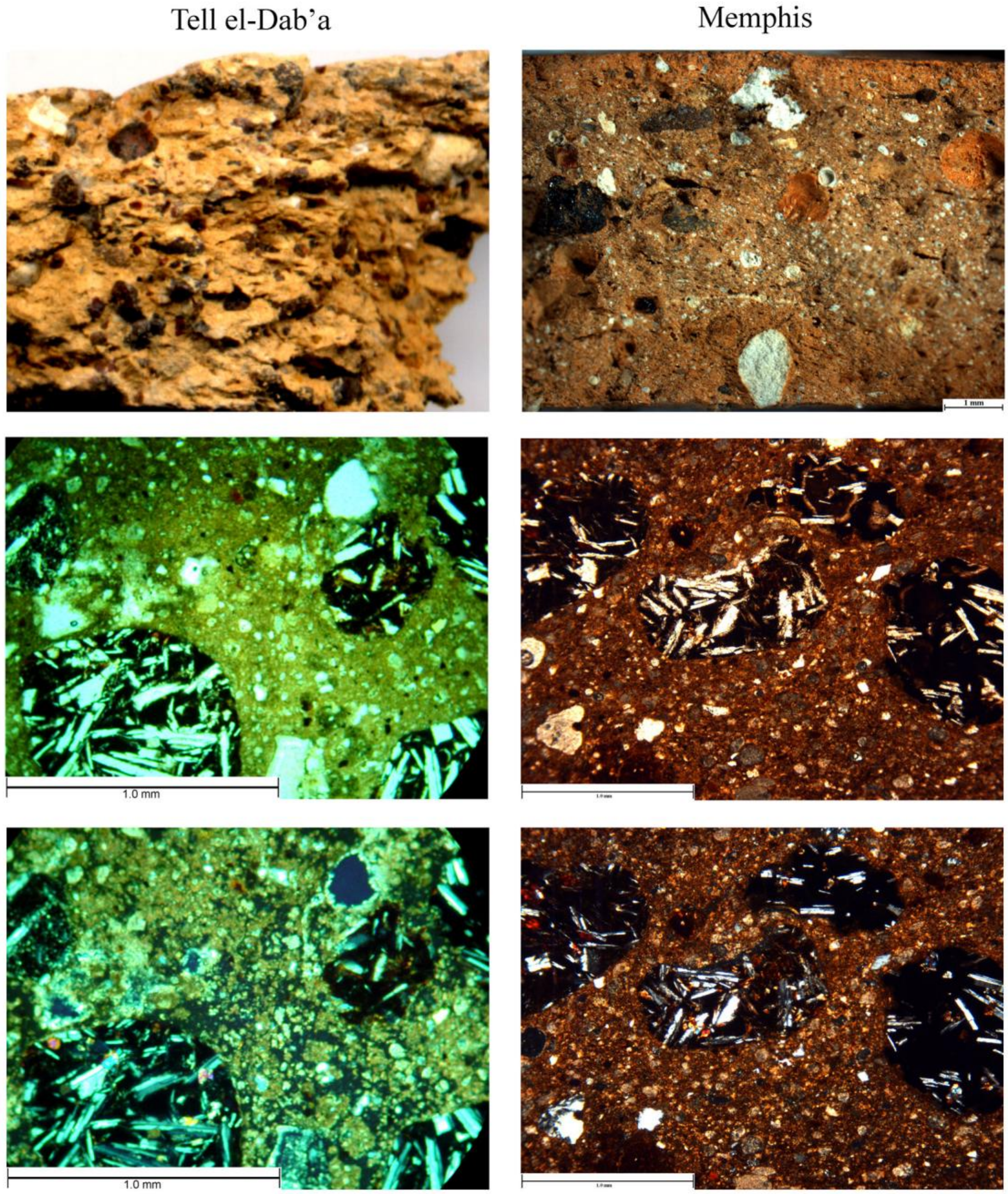


Fig. 6.9: Comparison of chip and thin section images (PPL and XPL), Tell el-Dab$^{c}$a TS# 215 (not analyzed by Cohen-Weinberger and Goren) and Ownby 19 (Group 1)




Some of the Memphis thin sections did not find correspondences with the Tell el-Dab$^{c}$a material. This was particularly the case with the Memphis outliers. Conversely, 44 of the 105 Tell el-Dab$^{c}$a thin sections were not similar to any of the Memphite samples. In particular, thin sections from Tell el-Dab$^{c}$a Groups A (North-west Syria/Cilicia) and J (Shephela/Wadi I$^{c}$ron) were not similar to the Memphis material, but these areas had not been identified as provenances for the latter. Thin sections were not available from Tell el-Dab$^{c}$a Groups C, F, H, and I, although their general petrographic descriptions suggested they were not comparable to the Memphis thin sections. Finally, as most of the Memphis thin sections were from levels dated later than the strata from which the Tell el-Dab$^{c}$a Canaanite jars derived, this may have resulted in fewer similarities between the two groups.

As a whole, the examination showed that only some of the Canaanite jars from Tell el-Dab$^{c}$a appeared comparable with those from Memphis. Further, the similarity was predominantly based on the clays employed and inclusion types, and less on inclusion size and amount. The lack of concordance was in part due to the large numbers of jars at Tell el-Dab$^{c}$a from excavated material that was both horizontally and vertically more extensive than the Memphis excavation. This produced a large quantity of Canaanite jar samples from Tell el- Dab$^{c}$a in comparison to the Memphite samples. Further, while the analysis of the Memphite MBA Canaanite jars is complete, the continued excavations at Tell el- Dab$^{c}$a produce a vast quantity of material that is still being processed. Secondly, the Tell el-Dab$^{c}$a jars derived from a wider geographic region, including areas that were not identified in the Memphite samples. Finally, the petrographic analysis suggested that the Memphite jars were all made of similar clays, whereas the Tell el-Dab$^{c}$a samples showed a greater variety of clays, sometimes from a single production area. This was probably due to the longer period covered by the Tell el-Dab$^{c}$a samples and more numerous jars, appearing to represent many workshops within each production area or a less consistent use of materials within workshops over time. The lack of concordance for a number of Memphite thin sections suggested additional comparisons were needed to clarify the relationship between the two corpora. Since all the thin sections of Canaanite jars from Tell el-Dab$^{c}$a could not be examined, it was decided to compare the sherds at the site with images of the sherd samples from Memphis.

## *6.3 Fabric Comparisons*

### 6.3.1 Fabrics examined

The examination of the Tell el-Dab$^{c}$a Canaanite jar sherd material took place at the site from October 5$^{th}$ to 25$^{th}$, 2008. A total of 365 chips (pieces of a sherd with a fresh break), mostly deriving from Canaanite jars, were examined under magnifications from 10x to 30x using a binocular microscope (stereoscope). They were compared to digital images of fresh breaks from the Memphite samples[183]. The Tell el-Dab$^{c}$a chips were described in the same manner as the Memphite samples (see form in Appendix I) and assigned a category as

[183] K. Kopetzky had noted similarities to the Tell el-Dab$^{c}$a material when she examined the Canaanite jars at Memphis. The current comparison benefited greatly from discussions with K. Kopetzky.

"slightly similar" or "similar". While "similar" was used for the thin sections to refer to samples with analogous clay, inclusions, or both; for the chip comparison "similar" denotes samples featuring the same fabric colour, types of inclusions, their size, shape, and frequency. This means that both the clay and inclusions must appear similar even though the petrographic analysis had noted the use of different clays in the same area. "Slightly similar" was applied to samples in which fabric colour and clay are comparable, but the inclusions, while analogous, occur in different sizes and/or frequency. As this probably relates to differences in vessel manufacture, the samples are still likely to derive from the same region.

Comparison initially focused on the sherd chips representing the Tell el-Dab$^{c}$a in-field fabric classification system. Material from each fabric group was inspected as well as several samples from within a single fabric group. The chips were predominantly from rim sherds[184] from strata b/3 to d/1 in area F/I dated to the 13$^{th}$ Dynasty as defined at Tell el-Dab$^{c}$a. Included amongst these chips were samples from 128 nearly complete vessels. An additional 14 chips were from nearly complete jars excavated in area F/II from strata D/3-E/1 dated to the 15$^{th}$ Dynasty. Finally, 32 of the examined chips were from Canaanite jars analyzed by Cohen-Weinberger & Goren (2004) from early 13$^{th}$ Dynasty to the 15$^{th}$ Dynasty strata. This assisted in relating the petrographic groups to their macroscopic appearance (Table 6.4). Unfortunately, few of the available chips were from the jars whose thin sections had been analyzed in Vienna.

Table 6.4: Tell el-Dab$^{c}$a (TeD) chips examined from Canaanite jars analyzed by Cohen-Weinberger & Goren (2004) and comparable Memphite samples. **=those that are similar, *= only slightly similar.

| Memphite Sample | TeD Vessel # | Pet. Group | Strata | Relative Date |
|---|---|---|---|---|
| | 4779 | B3 | b/3 | 13$^{th}$ Dynasty |
| | 5203 | B2 | b/1 | 15$^{th}$ Dynasty |
| | 6979 | K | b/3-2 | Late 13$^{th}$ Dynasty |
| | 6983 | B2 | a/2 | 15$^{th}$ Dynasty |
| | 6991 | H | b/3-2 | Late 13$^{th}$ Dynasty |
| | 2497G | E (Akkar) | D/3 | 15$^{th}$ Dynasty |
| | 2532C | D | G | 13$^{th}$ Dynasty |
| | 2660B | B2 | G | 13$^{th}$ Dynasty |
| | 3955A | D | b/3 | 13$^{th}$ Dynasty |

[184] Comparing the Tell el-Dab$^{c}$a rim sherds to Memphite body sherds may have resulted in fewer identified similarities as potters can use different recipes for the various parts of vessels, e.g.the Shipibo-Conibo potters of Peru that employ one recipe for the body and another for the neck/rim (Rice 1987: 121, 230). However, the clay and inclusion types are likely to be similar with most differences based on proportions of clay and temper.

| Memphite Sample | TeD Vessel # | Pet. Group | Strata | Relative Date |
|---|---|---|---|---|
| Ow 42* | 4030B | K | G | 13th Dynasty |
| | 4099C | I | b/2 | Late 13th Dynasty |
| | 4426C | H | a/2 | 15th Dynasty |
| Ow 45* | 4537A | B3 | E/2 | Early 15th Dynasty |
| Ow 43** | 4551B | B2 | b/3 | 13th Dynasty |
| Ow 49 & Ow 55** | 4551C | B2 | b/2 | Late 13th Dynasty |
| | 4551E | K | b/2 | Late 13th Dynasty |
| | 4551F | G | D/3 | 15th Dynasty |
| Ow 32* | 4551L | B2 | b/3 | 13th Dynasty |
| | 4552E | B2 | E/1 | 15th Dynasty |
| | 4553A | B2 | b/3 | 13th Dynasty |
| | 4630A | B3 | b/3 | 13th Dynasty |
| | 4630D | E (Akkar) | b/3-2 | Late 13th Dynasty |
| Ow 43* | 4632D | B3 | b/3-2 | Late 13th Dynasty |
| | 4636A | F | no context | |
| | 5642A | A1 | d/1? | Early 13th Dynasty? |
| | 5822Q | B1 | b/1 | Early 15th Dynasty |
| | 5894C | B1 | d/1 | Early 13th Dynasty |
| | 6176E | B3 | d/1 | Early 13th Dynasty |
| | K478 | B3 | G-H | Early 13th Dynasty |
| Ow 35* | K2810 | B1/B2 | disturbed | |
| | K3456 | K | disturbed | |
| | K3634 | Undeterm. | d/1 | Early 13th Dynasty |

### 6.3.2 Results

The results of the comparison of the Canaanite jar sherds from both sites identified additional samples at Tell el-Dab^c^a that were analogous to those from Memphis. In total, 25 chips were "slightly similar", while 41 were "similar" to the Memphite examples (Table 6.5). Many other samples were more superficially comparable to the Memphite jars, but rigorous criteria were applied as it had been noted that visually similar fabrics could derive from different geographic areas. Only a small number were identical, as the natural variability in the Canaanite jar fabrics precluded perfect matches.

Table 6.5: Chips examined from mostly complete jars and rims (K numbers) similar to Memphite samples[185]

| Memphite Sample | TeD Vessel # | Strata | Relative Date |
|---|---|---|---|
| Ow 35 & Ow 40 | 4776 | | |
| Ow 40 | 4781 | | |
| Ow 34 | 5897 | b/1-a/2 | 15th Dynasty |
| Ow 34 | 6018 | | |
| Ow 11 | 2497L | D2 | Late 15th Dynasty |
| Ow 35 | 2532E | G | Early 13th Dynasty |
| Ow 14 | 2532F | G | Early 13th Dynasty |
| Ow 32 | 4030D | E/2 | Early 15th Dynasty |
| Ow 42 | 4547A | | |
| Ow 31 | 4549B | | |
| Ow 56 | 4550D | | |
| Ow 34 | 4551D | E/3 | Late 13th Dynasty |
| Ow 44 | 4552B | | |
| Ow 24 | 6793A | D/2 | Late 15th Dynasty |
| Ow 51 & Ow 54 | 6794J | D/2 | Late 15th Dynasty |
| Ow 49 | 8823E | D/3 | 15th Dynasty |
| Ow 18 | 9020T | E/1 – early D/3 | 15th Dynasty |
| Ow 50 | K2091 (3) | | |
| Ow 9 | K2268 | | |
| Ow 26 | K2664 (16) | (c)-b/3 | Mid 13th Dynasty |
| Ow 56 | K2771 (37) | c-d/1 | Early 13th Dynasty |
| Ow 50 | K2817 (27) | d/1 | Early 13th Dynasty |
| Ow 31 | K2817 (70) | d/1 | Early 13th Dynasty |
| Ow 31 | K2817 (74) | d/1 | Early 13th Dynasty |
| Ow 22 | K2817 (120) | d/1 | Early 13th Dynasty |
| Ow 22 | K2817 (122) | d/1 | Early 13th Dynasty |
| Ow 33 & Ow 44 | K2821 (6) | c | Early 13th Dynasty |
| Ow 18 | K3183 (2) | D/2 | Late 15th Dynasty |
| Ow 32 | K3380 (13) | d/2 | Late 12th Dynasty |
| Ow 14 | K3417 (7) | D/2 | Late 15th Dynasty |
| Ow 8 | K3417 (8) | D/2 | Late 15th Dynasty |
| Ow 8 & Ow 14 | K3582 (7) | D/2-1 | Late 15th Dynasty |
| Ow 50 | K4249 (5) | b/3 | Mid 13th Dynasty |
| Ow 50 | K4249 (7) | b/3 | Mid 13th Dynasty |
| Ow 31 | K8424 (2) | G/1-3 – F | 13th Dynasty |
| Ow 5 | FN 10 | E/1 – early D/3 | 15th Dynasty |
| Ow 18 | FN 105 | E/1 – early D/3 | 15th Dynasty |
| Ow 13 | FN 112 | E/1 – early D/3 | 15th Dynasty |
| Ow 8 | FN 124 | E/1 – early D/3 | 15th Dynasty |
| Ow 31 | FN 358 | E/1 – early D/3 | 15th Dynasty |
| Ow 8 | FN 678 | E/1 – early D/3 | 15th Dynasty |

185 For some sherds the strata was not given on the bag and they have not yet been published.

Fabrics containing basalt inclusions were rare, as noted from the petrographic analysis, and only a few of the Tell el-Dab$^{c}$a examples contained these inclusions. Since the petrographic Group A fabrics are made from a very red clay, they were easily separated from the Group E fabrics (Cohen-Weinberger & Goren 2004: 71-73, 76). This left 5 samples with basalt inclusions. Only one appeared similar to a Memphite Group 1 sample and was dated to the late 15$^{th}$ Dynasty (Fig. 6.10).

Some of the Tell el-Dab$^{c}$a samples were "slightly similar" to the chips representing Memphis Group 2, while several were "similar" (Fig. 6.11). These chips featured large reddish chalk inclusions in a reddish-yellow matrix. Memphis Group 3, believed to have been imported from Coastal Lebanon, was the most similar to the chips at Tell el-Dab$^{c}$a (Figs. 6.12 and 6.13). For these samples, the cream to reddish matrix contained many bioclast inclusions (appearing as light to dark gray shiny round fragments) and minor amounts of other grains. As the coast of Lebanon was suggested as the dominant region exporting jars to both sites, the concordance was not surprising. Tell el-Dab$^{c}$a chips with plentiful, well-sorted sand in a reddish-yellow matrix were similar to those in Memphis Group 4, assigned to coastal northern Palestine (Fig. 6.14). At Tell el-Dab$^{c}$a they came mostly from jars dated to the 15$^{th}$ Dynasty. Earlier samples likely to come from the northern coast of Palestine were less analogous to the Memphite jars.

Fig. 6.10: Chip comparison for Memphis Group 1

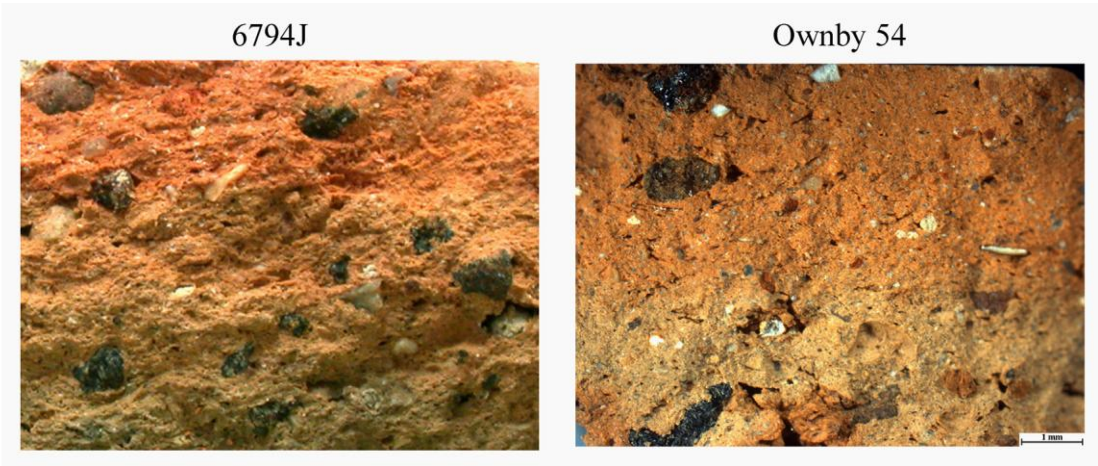


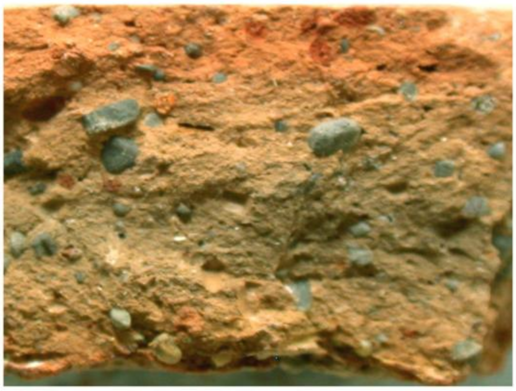
Fig. 6.11: Chip comparison for Memphis Group 2

K2817 (120)

Ownby 22

Fig. 6.12: Chip comparison for Memphis Group 3 (subgroup of samples)

4551C



Ownby 55

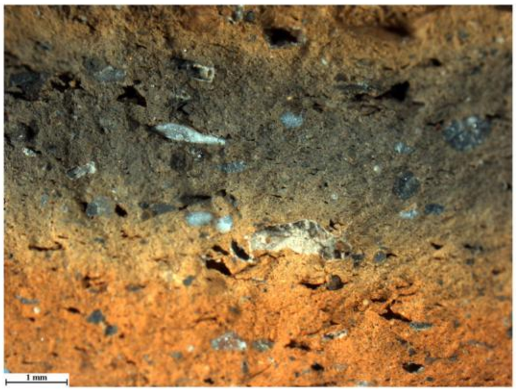


Fig. 6.13: Chip comparison for Memphis Group 3

4030D

Ownby 32

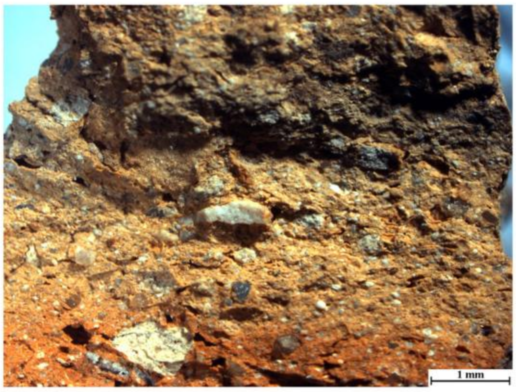
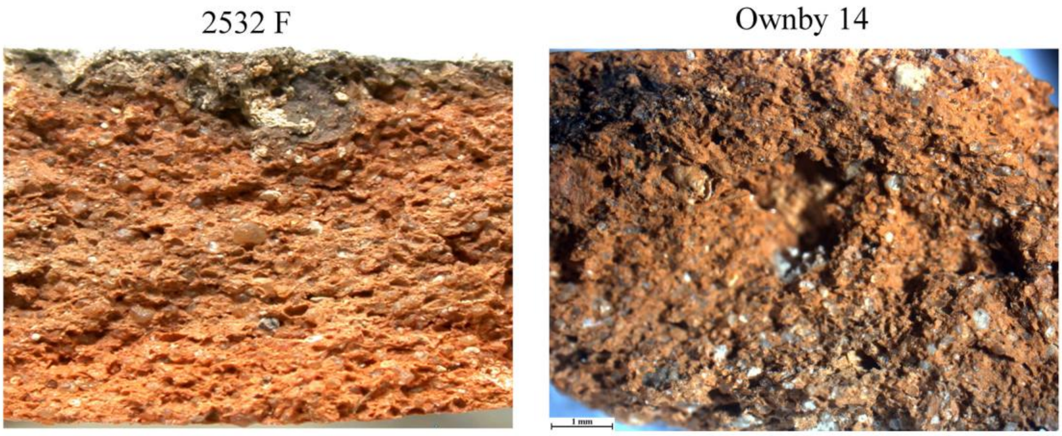


Fig. 6.14: Chip comparison for Memphis Group 4

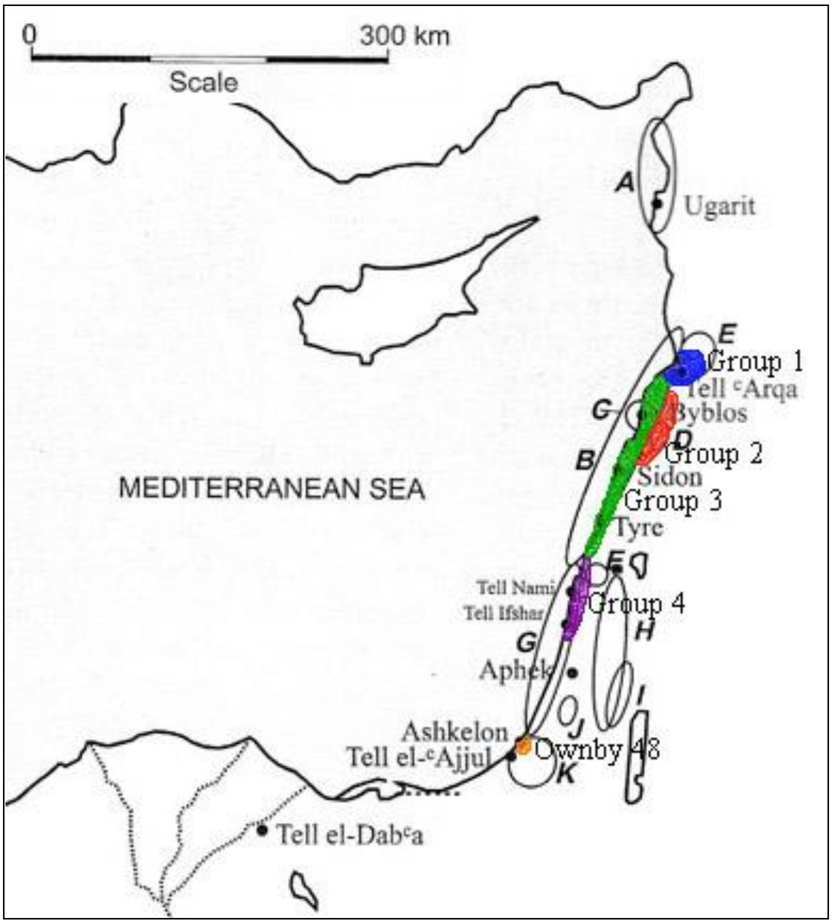



As the majority of the Memphite samples date to a period contemporary with the 15$^{th}$ Dynasty at Tell el-Dab$^{c}$a, the better concordances with material of this date was expected. This also suggests that if more samples had been available from 15$^{th}$ Dynasty contexts, additional similarities would have been found. Finally, no comparable sherds were identified for the Memphite outliers. This included Ownby 48, assigned a provenance in southern Palestine, an area identified through petrographic analysis as exporting jars to Tell el-Dab$^{c}$a (Cohen-Weinberger & Goren 2004: 79-80). The lack of identified comparanda to the outliers may suggest that these fabrics are also rare at Tell el-Dab$^{c}$a. As there were Canaanite jars from Tell el-Dab$^{c}$a that could not be studied, examining additional samples would in all likelihood produce more comparibilities to the Memphis material. That some of the Memphite fabrics represent vessels not imported to Tell el-Dab$^{c}$a remains a possibility, as jars could have come to Memphis via other sites in the Delta.

While the number of "similar" sherds between Tell el-Dab$^{c}$a and Memphis may appear small, their visual comparability suggests that at least some of the jars at both sites were produced in the same workshops along the Levantine coast. A comparable sample was found at Tell el-Dab$^{c}$a for each of the major petrographic groups identified for the Memphis jars. Along with the thin section comparison, these observations suggest that most of the jars found at Memphis were probably exported from the same areas that sent material to Tell el-Dab$^{c}$a: the Akkar Plain (Memphis Group 1= Tell el-Dab$^{c}$a Group E), inland Lebanon (Memphis Group 2= Tell el-Dab$^{c}$a Groups B3 and D), coastal Lebanon (Memphis Group 3= Tell el-Dab$^{c}$a Groups B1-B3), and northern coastal Palestine (Memphis Group 4= Tell el-Dab$^{c}$a Group G) (Fig. 6.15). However, Tell el-Dab$^{c}$a received jars from areas that Memphis did not, such as northwest Syria/Cilicia (Group A), Mount Carmel (Group F), the Judea, Samaria, or Galilee mountain region (Groups H and I), and the Shephela/Wadi I$^{c}$ron area (Group J and some from Group K). This may be related to the fact that strata from Tell el-Dab$^{c}$a cover a longer period and came from a larger excavation than those at Memphis.

The macroscopic comparison provided further support to the petrographic examination which had suggested that similar jars were present at both sites. The examination of chips confirmed that jars comparable to Memphis Group 1 were present at Tell el-Dab$^{c}$a, something that had been in doubt after the petrographic comparison. However, the petrographic results showed that visually dissimilar samples could contain the same types and range of inclusions, suggesting they were produced in the same region. Thus, samples examined macroscopically and not deemed similar to the Memphite material, may still have been produced in the same areas as samples from Memphis.

Fig. 6.15: Map of provenance groups for the Tell el-Dab$^{c}$a and Memphite (in colour) MBA Canaanite jars (base map from Cohen-Weinberger & Goren 2004: Fig. 1)



## *6.4 Association between Fabrics and Vessel Forms for Tell el-Dab$^{c}$a*

For the 41 Tell el-Dab$^{c}$a Canaanite jar sherds that were similar to the Memphis samples, line drawings have been published or provided for thirteen examples[186]. Drawings of the other examined jars are unpublished. Unlike the Memphis material which was mostly body sherds and a few rim, base, and handle sherds, more complete jars were uncovered at Tell el-Dab$^{c}$a. As some of the jars had been used for infant burials, their necks and rims had often been removed, leaving only the lower three-fourths of the vessel. Thus, for all except one line drawing, the rims are missing; five drawings are of bases only. This means that comparison to the drawn rim sherds from Memphis is not possible. However, the macroscopic similarity between the sherds from both sites meant that for the Tell el-Dab$^{c}$a drawn vessels, a tentative provenance could be given.

One drawn sherd was similar to the samples in Memphis Group 1 assigned to the Akkar Plain, while a second one resembled the Memphis Group 2 sherds, suggested as imported from inland Lebanon (Fig. 6.16). Not surprisingly, the bases are noticeably different with the former being flat and the latter rounded. Of the drawn vessels similar to samples from Memphis Group 3, designated as coming from coastal Lebanon, there are two (5897 and FN 358) with bodies more slender than the others (Fig. 6.17). For the vessels with rounder bodies, their bases also appear round, while the slender bodied vessels have a flat base. Seven of the drawn vessels had fabrics analogous to those in Memphis Group 4, assigned to the northern coast of Palestine (Fig. 6.18). Once again, two body types are seen, a more triangular type with a flat base and a more ovoid type with a round base. The similarity in shape between 5897 and 9020T, assigned to coastal Lebanon and northern coastal Palestine respectively based on similarities to Memphis samples, suggests that workshops in different areas may have produced vessels of comparable shape. Handles appear to vary within production regions and between the different postulated areas, ranging from those that are more semi-circular (4030D) to those that are more triangular (9020T). These differences and similarities between vessel forms assigned to different potential regions are not related to chronological changes as the jars derive from strata dated to the 15$^{th}$ Dynasty (Table 6.5).

[186] This discussion would not have been possible without the assistance of B. Bader and D. Aston in acquiring line drawings.

Fig. 6.16: Line drawings of Tell el-Dab$^{c}$a jars with fabrics similar to those in Memphis Groups 1 ("Akkar Plain") and 2 ("Inland Lebanon") (Hein & Jánosi 2004: Figs. 95 and 157)

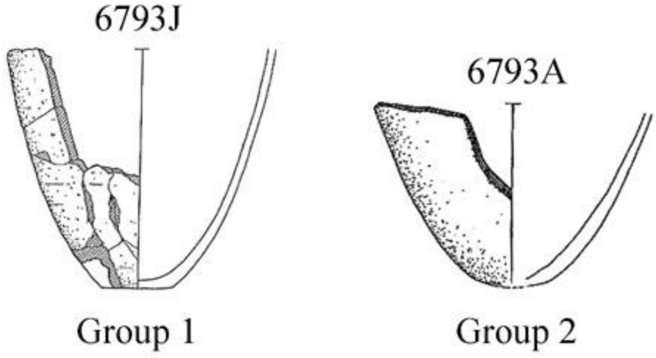



Fig. 6.17: Line drawings of Tell el-Dab$^{c}$a jars with fabrics similar to those in Memphis Group 3, "Coastal Lebanon" (Aston 2004a: Plate 287; Forstner-Müller 2008: Figs. 154 and 247; FN 358 courtesy of D. Aston)

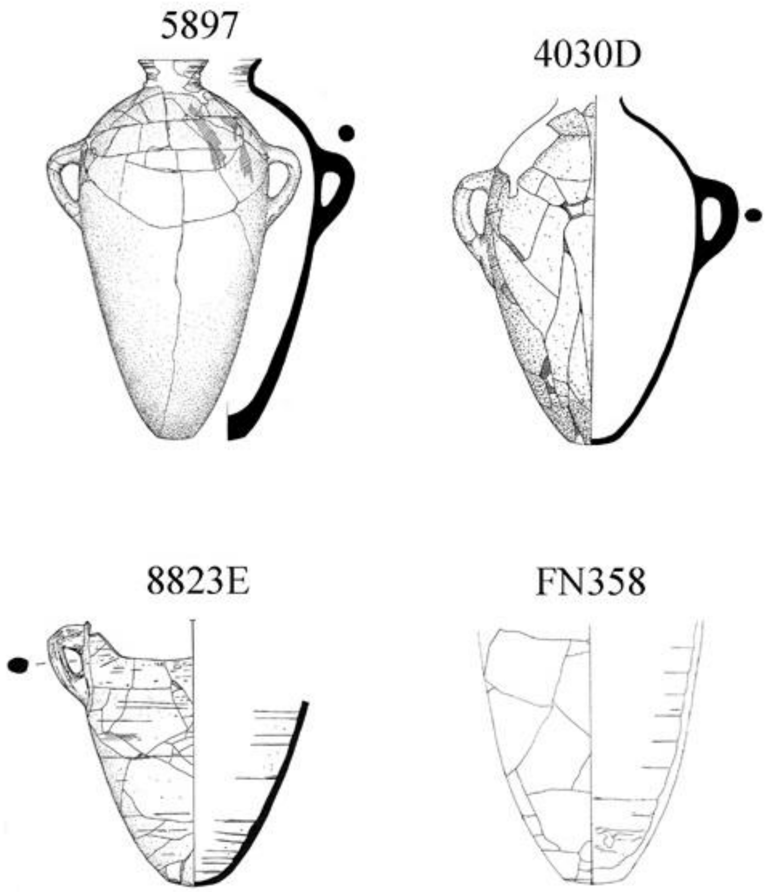
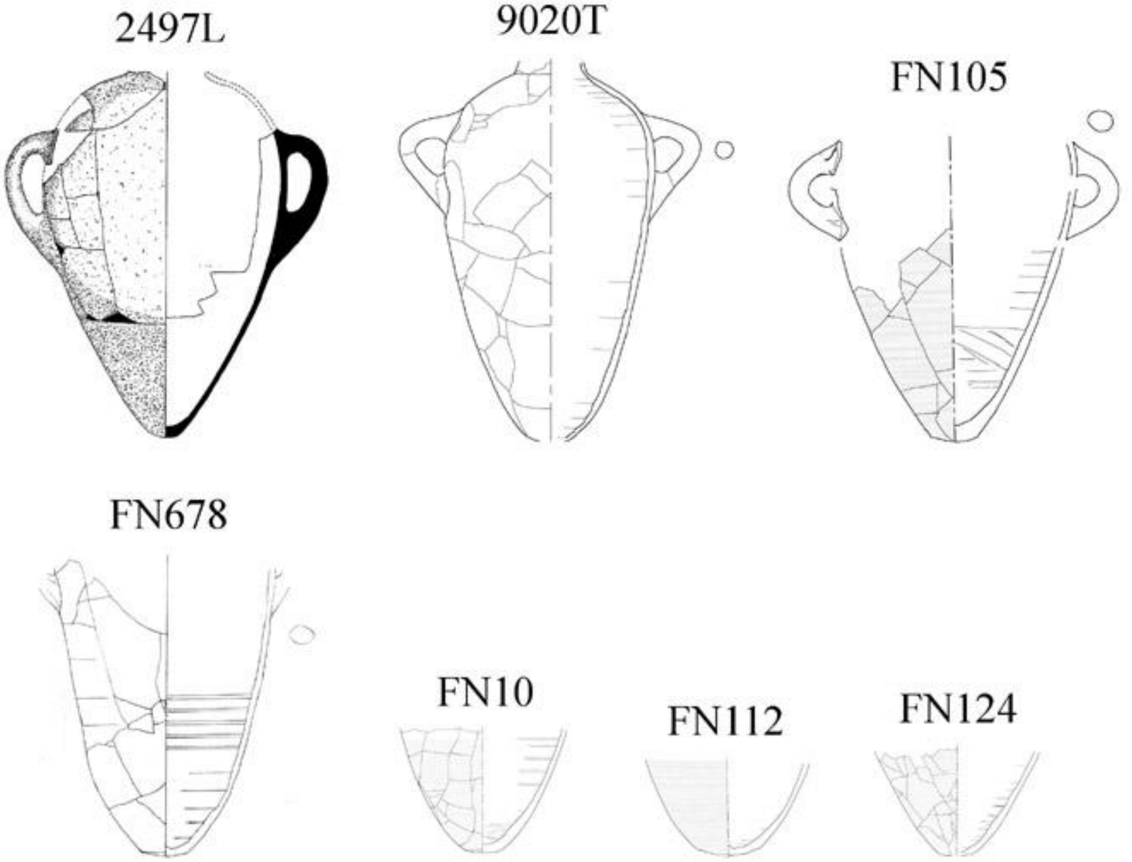


Fig. 6.18: Line drawings of Tell el-Dab[c]a jars with fabrics similar to those in Memphis Group 4, "Northern Coastal Palestine" (Bietak 1991b: Fig. 290, 9020T; FN#s courtesy of D. Aston)




Comparison of these few line drawings of jars from Tell el-Dab[c]a to drawings of Canaanite jars from the Levant (there called storage jars) is difficult. Because fabrics are not fully described, the possibility exists that jars excavated at a single site are a combination of those locally produced as well as imported examples. Finding vessels of comparable shape at a site does not therefore confirm that the jars were made at the site or nearby. Nevertheless, a few comparisons will illustrate that patterns noted for the Tell el-Dab[c]a jars are also seen in the Levant. Contemporary MB II storage jars from Lachish also show variation in the bodies, with some more slender and others featuring an ovoid shape (Fig. 6.19; Singer-Avitz 2004: 996). Likewise, the bases can be flat or rounded. Storage jars from Shiloh are similar in appearance (Fig. 6.20; Bunimovitz and Finkelstein 1993: 115, 117). Overall, both the jars from the Levant and those at Tell el-Dab[c]a illustrate that the relationship between fabric, vessel shape, and provenance is a complex one and that only through petrographic examination of vessels of known fabric and form can clear correlations be revealed.

Fig. 6.19: MB II storage jars from tombs at Lachish (Singer-Avitz 2004: Figs. 17.8, 17.10, and 17.13)

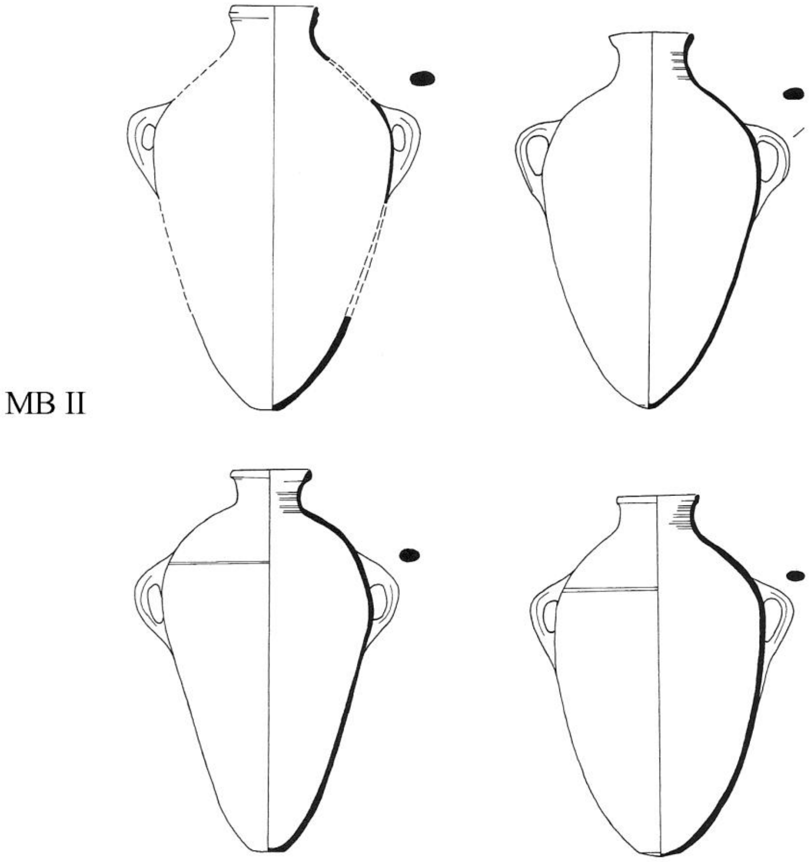
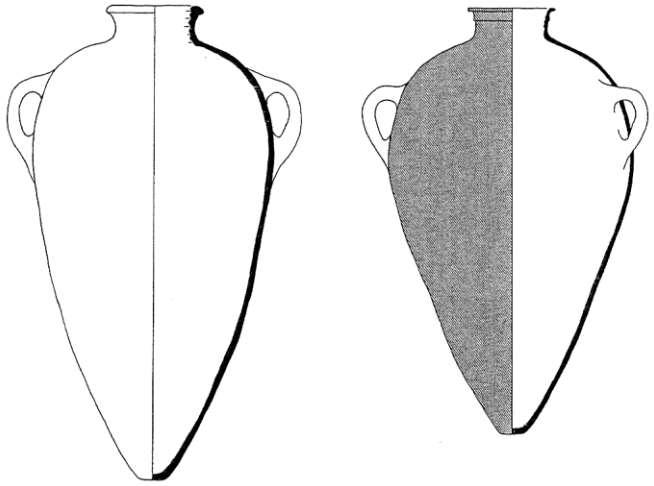



Fig. 6.20: MB III storage jars from Shiloh (Bunimovitz and Finkelstein 1993: Figs. 6.18 and 6.20).



## 6.5 Conclusions

Comparison of the MBA Canaanite jars from Memphis with those from Tell el-Dab$^{c}$a aimed to establish the similarities and differences between the two corpora. Through petrographic and macroscopic comparisons, the jars from both sites were shown to be of related fabrics and probably derived from similar areas in the Levant. This suggests the areas exporting jars to Tell el-Dab$^{c}$a were likely the same as those producing jars found at Memphis, i.e. the Akkar Plain, inland Lebanon, coastal Lebanon, and northern coastal Palestine. Since the few jars found at Memphis come from areas producing many jars found at Tell el-Dab$^{c}$a, the Memphis jars appear to derive from the more productive manufacturers in the Levant. There are, however, differences between the jars at Tell el-Dab$^{c}$a and those at Memphis. Rare imported vessels at Tell el-Dab$^{c}$a, such as those from north-western Syria/Cilicia and inland Palestine, are absent at Memphis. Of particular interest is the absence at Memphis of jars coming from inland Palestine, as the material from Tell el-Dab$^{c}$a suggests this area specialized in producing only Canaanite jars. Although they are rare at the site. Some of these differences are probably the result of the longer chronological span of imported jars and the greater extent of the excavations at Tell el-Dab$^{c}$a in comparison to Memphis. However, the jars may have come to Memphis from another site in the Delta, and possibly passed through several hands before reaching the site. Nevertheless, the fact that Tell el-Dab$^{c}$a was one of the largest sites in the Delta with a habour located on the Pelusiac branch of the Nile, giving direct access to Memphis by river, make it likely that the jars came to Tell el-Dab$^{c}$a before being distributed elsewhere. The results of the current study are thus consistent with Memphis and Tell el-Dab$^{c}$a having some degree of contact with each other.

# Chapter 7: Comparison between Memphite MBA and LBA Canaanite Jars

## *7.1 Introduction*

In the current study, petrographic examination of samples of the MBA Canaanite jars from Memphis identified the raw materials utilized in their production and suggested several possible locations where these vessels were manufactured. This provided insight into which areas of the Levant were trading partners with Egypt during the late MBA. In previous studies, petrographic and chemical analyses of selected samples of LBA Canaanite jars from Memphis had postulated areas that appeared to be exporting these jars to Egypt in this period (Smith *et al*. 2000; Bourriau *et al*. 2001; Serpico *et al*. 2003; Smith *et al*. 2004). Thus, examination of the LBA data in relation to that from the MBA should reveal how production locations and methods of manufacture changed from the MBA to the LBA.

## *7.2 Petrographic Comparisons Results*

LBA Canaanite jars from Memphis were analyzed petrographically and chemically as part of a larger study of LBA Canaanite jars in Egypt, which included samples from the sites of Amarna and Saqqara (Smith *et al*. 2000; Bourriau *et al*. 2001; Smith *et al*. 2004). Compositional data were acquired through NAA (Al-Dayel 1995) and ICP-AES (Smith *et al*. 2004: 56). Both the LBA thin sections and the compositional data provided material for comparison to the MBA Canaanite jars. In the current study, thin sections of 51 samples were examined and compared to the MBA thin sections (Table 7.1). They came from Kom Rabi'a levels V to 0 dated from the late Second Intermediate Period – early 18$^{th}$ Dynasty to the disturbed surface, below which was a mix of Third Intermediate and 20$^{th}$ Dynasty material designated Level I (Aston & Jeffreys 2007). The samples were taken to illustrate the range of fabrics seen in the field and were classified into fabric groups. Brief descriptions of the LBA petrographic groups is given below to facilitate comparison. These are based on the published information, but were supplemented by the author's own observations, particularly on features indicative of production technology. Fig. 7.1 shows the interpreted provenance of the six identified LBA petrographic groups, while Fig. 7.2 illustrates the areas identified as production regions for the MBA petrographic groups. Table 7.2 lists the petrographic group assignments for each LBA sample. Discussions with L. Smith were invaluable for this chapter.

Table 7.1: List of LBA thin sections from Kom Rabi'a, including sherd number, fabric, context, level, and relative date of level

| TS # | Sherd # | Fabric | Context | Level | Relative Date |
|---|---|---|---|---|---|
| 59 | 8055 | P11 | RAT 31 | 0 | disturbed surface |
| 60 | 12070 | P11 | RAT 154 | IIA | Mid – Late 19th Dynasty |
| 61 | 2385 | P16 | RAT 367 | IIIA | Late 18th – Early 19th Dyn. |
| 62 | 2390 | P16 | RAT 233 | I | 20th Dynasty – TIP |
| 63 | 5319 | P16 | RAT 765 | III | Mid 18th – Early 19th Dyn. |
| 64 | 6875 | P16 | RAT 192 | IIIA/IIB | Late 18th – Mid 19th Dyn. |
| 65 | 10731 | P16 | RAT 1291 | IIB/A | Early – Late 19th Dynasty |
| 70 | 10776 | P52/P40? | RAT 1194 | WC III | Early 18th – Early 19th Dyn. |
| 74 | 2383 | P30 | RAT 409 | IIIA | Late 18th – Early 19th Dyn. |
| 75 | 10733 | P30 | RAT 230 | IIA | Mid – Late 19th Dynasty |
| 76 | 10734 | P30 | RAT 93 | IIA | Mid – Late 19th Dynasty |
| 77 | 10750 | P30 | RAT 218 | IIA | Mid – Late 19th Dynasty |
| 79 | 2387 | P31 | RAT 450 | IV | Early – Mid 18th Dynasty |
| 80 | 3841 | P31 | RAT 125 | IIIA/IIB | Late 18th – Mid 19th Dyn. |
| 82 | 10764 | P31 | RAT 385 | IIIA/B | Mid 18th – Early 19th Dyn. |
| 83 | 8952 | P33 | RAT 417 | IIIB | Mid – Late 18th Dynasty |
| 84 | 8997 | P33 | RAT 1037 | IIIA | Late 18th – Early 19th Dyn. |
| 85 | 9176 | P33 | RAT 1130 | WC III | Early 18th – Early 19th Dyn. |
| 89 | 2736 | P40 | RAT 94 | IIA | Mid – Late 19th Dynasty |
| 90 | 3301 | P40 | RAT 107/8 | IIA | Mid – Late 19th Dynasty |
| 91 | 8224 | P40 | RAT 103 | II/IV | Mixed contexts |
| 98 | 8032 | P40 | RAT 31 | 0 | disturbed surface |
| 99 | 10729 | P40 | RAT 367 | IIIA | Late 18th – Early 19th Dyn. |
| 100 | 14222 | P40 | RAT 493 | IIIA | Late 18th – Early 19th Dyn. |
| 145 | 1242 | P30 | RAT 447 | IIB | Early – Mid 19th Dynasty |
| 146 | 974/975 | P31 | RAT 389 | IIIA | Late 18th – Early 19th Dyn. |
| 147 | 8219 | P16 | RAT 103 | II/IV | Mixed contexts |
| 148 | 14283 | P40 | RAT 412 | IIB | Early – Mid 19th Dynasty |
| 149 | 13757 | P51 | RAT 109 | IIB | Early – Mid 19th Dynasty |
| 150 | 2825 | P40 | RAT 94 | IIA | Mid – Late 19th Dynasty |
| 151 | 3971 | P31 | RAT 662 | IV | Early – Mid 18th Dynasty |
| 152 | 3885 | P33 | RAT 125 | IIIA/IIB | Late 18th – Mid 19th Dyn. |
| 153 | 18003 | P30 | RAT 370 | IIB | Early – Mid 19th Dynasty |
| 154 | 13523 | P16 | RAT 398 | IIIA | Late 18th – Early 19th Dyn. |
| 155 | 10780 | P30 | RAT 214 | IIA | Mid – Late 19th Dynasty |
| 200 | 8107 | P71 | RAT 31 | 0 | disturbed surface |
| 206 | 14159 | P70 | RAT 103 | II/IV | Mixed contexts |
| 216 | 11423 | P51 | RAT 203 | IIA | Mid – Late 19th Dynasty |
| 217 | 3005 | P51 | RAT 34 | I | 20th Dynasty – TIP |
| 218 | 11615 | P70 | RAT 54+80 | IIA | Mid – Late 19th Dynasty |
| 220 | 11542 | P33 | RAT 50+95 | 0/I | TIP |
| 221 | 13772 | P40 | RAT 109 | IIB | Early – Mid 19th Dynasty |
| 224 | 3004 | P51 | RAT 34 | I | 20th Dynasty – TIP |
| 225 | 8058 | P51 | RAT 31 | 0 | disturbed surface |

| TS # | Sherd # | Fabric | Context | Level | Relative Date |
|---|---|---|---|---|---|
| 245 | 5320 | P16 | RAT 765 | III | Mid 18th – Early 19th Dyn. |
| 246 | 3968 | P16 | RAT 509 | IV | Early – Mid 18th Dynasty |
| 247 | 2391 | P16 | RAT 233 | I | 20th Dynasty – TIP |
| 248 | 3969 | P16 | RAT 509 | IV | Early – Mid 18th Dynasty |
| 249 | 5322 | P16 | RAT 765 | III | Mid 18th – Early 19th Dyn. |
| 251 | 2532 | P33 | RAT 707 | V | Late SIP – Early 18th Dyn. |
| 252 | 2530 | P31 | RAT 707 | V | Late SIP – Early 18th Dyn. |

*SIP=Second Intermediate Period; TIP=Third Intermediate Period

Fig. 7.1: Map of proposed provenance assignments for LBA Canaanite jar petrographic groups (based on Smith *et al*. 2004: Figs. 4.17 and 4.18)

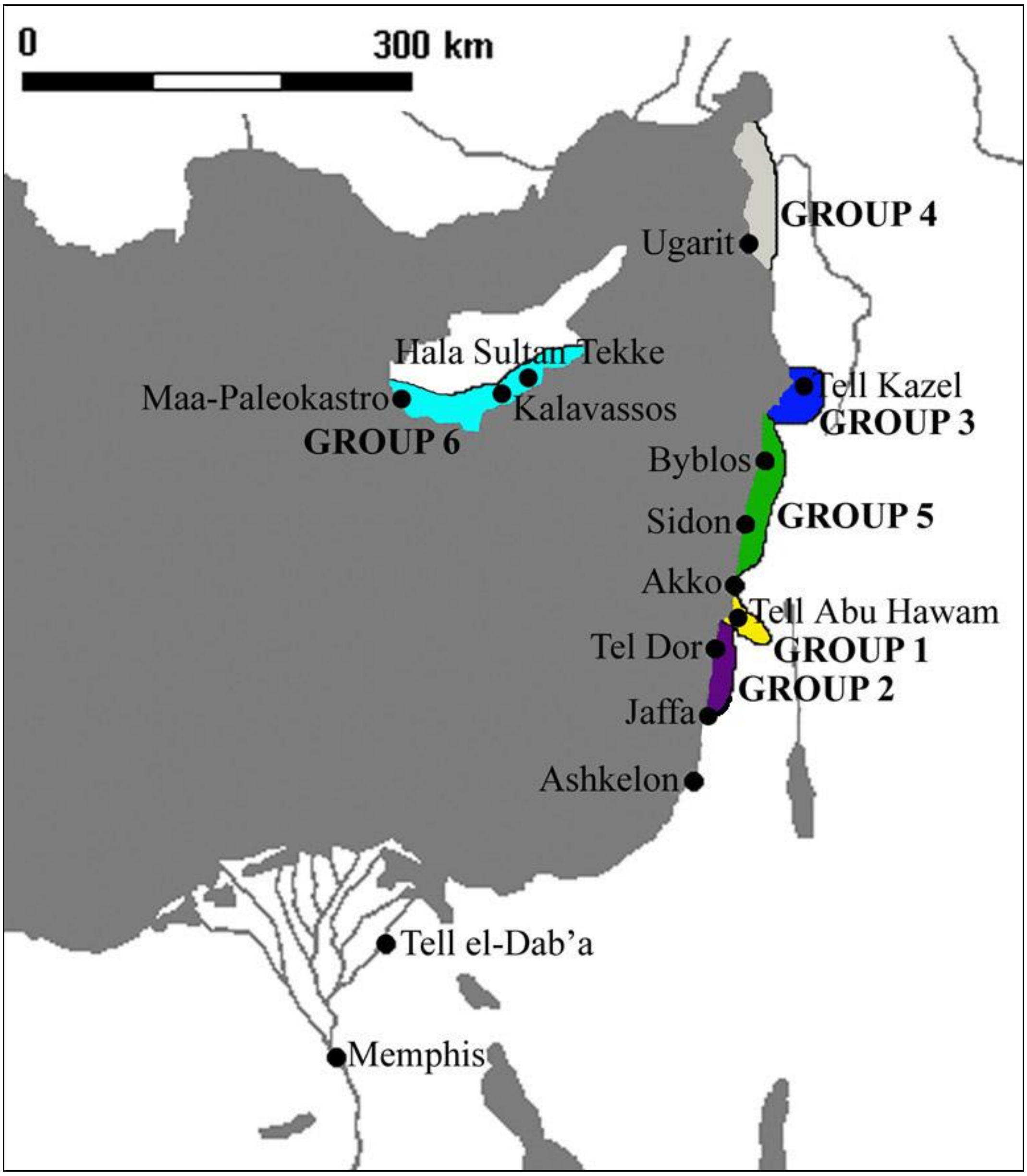


Fig. 7.2: Map of proposed provenance assignments for MBA Canaanite jar petrographic groups

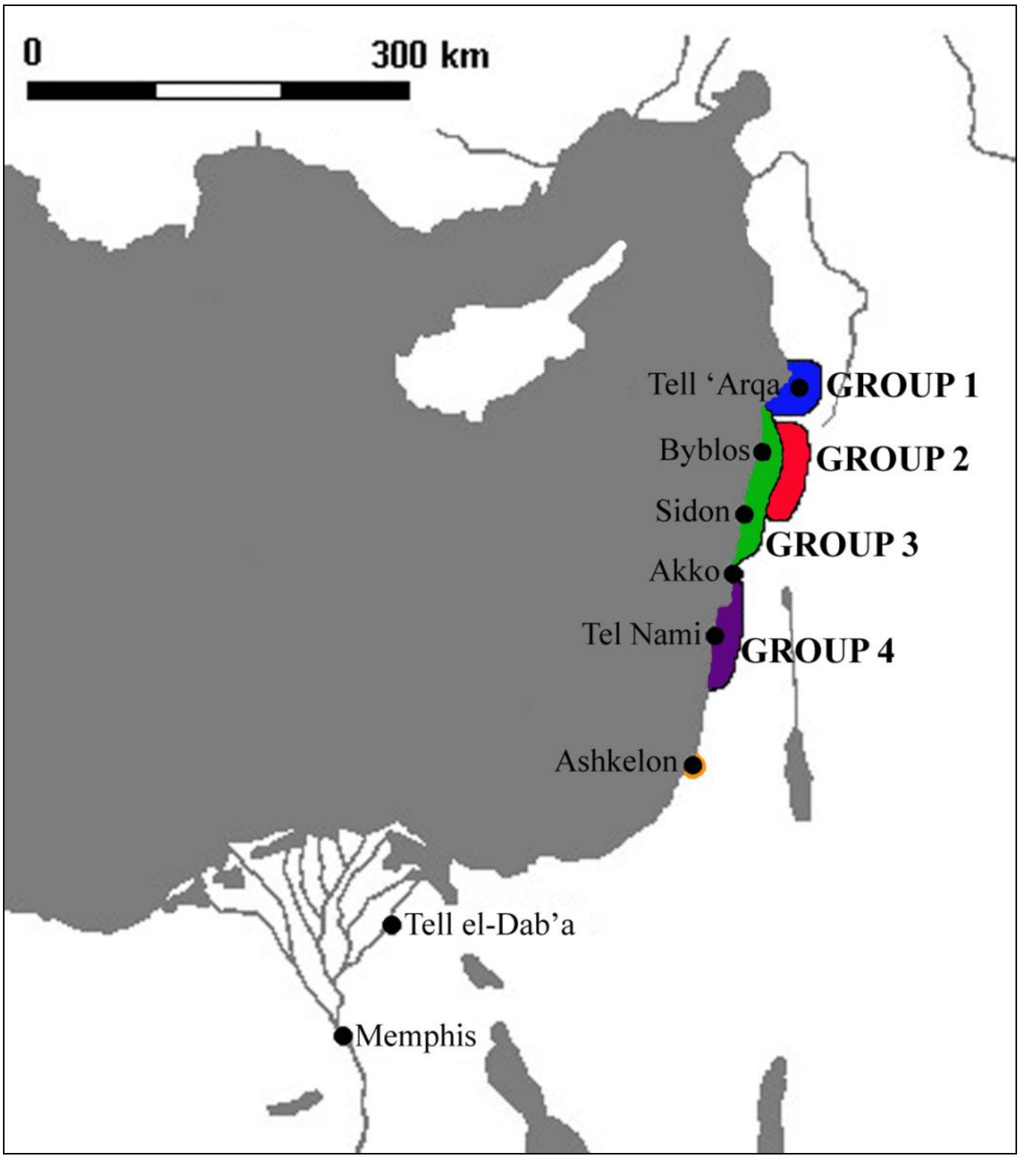



Table 7.2: Assigned provenance for the LBA thin sections from Memphis, including sherd number, fabric, petrographic group, and type of chemical data

| TS # | Sherd # | Fabric | Pet Group[187] | Provenance | Data Type |
|---|---|---|---|---|---|
| 59 | 8055 | P11 | 1 | Haifa Bay | |
| 60 | 12070 | P11 | 1 | Haifa Bay | |
| 61 | 2385 | P16 | 3b | Akkar Plain | |
| 62 | 2390 | P16 | 3a | Akkar Plain | NAA |
| 63 | 5319 | P16 | 3b | Akkar Plain | |
| 64 | 6875 | P16 | 3a | Akkar Plain | |

[187] Group 3 has been divided into Group 3a (Neogene clay) and Group 3b (calcareous clay) for the purposes of this study, see below.

| TS # | Sherd # | Fabric | Pet Group[187] | Provenance | Data Type |
|---|---|---|---|---|---|
| 65 | 10731 | P16 | 3b | Akkar Plain | |
| 70 | 10776 | P52/P40? | 6 | Southern Cyprus | |
| 74 | 2383 | P30 | 1 | Haifa Bay | |
| 75 | 10733 | P30 | 1 | Haifa Bay | |
| 76 | 10734 | P30 | 1 | Haifa Bay | ICP |
| 77 | 10750 | P30 | 1 | Haifa Bay | ICP |
| 79 | 2387 | P31 | 2 | Northern Coastal Palestine | |
| 80 | 3841 | P31 | 2 | Northern Coastal Palestine | |
| 82 | 10764 | P31 | 2 | Northern Coastal Palestine | |
| 83 | 8952 | P33 | 5 | Coastal Lebanon | ICP |
| 84 | 8997 | P33 | 5 | Coastal Lebanon | |
| 85 | 9176 | P33 | 5 | Coastal Lebanon | |
| 89 | 2736 | P40 | 6 | Southern Cyprus | |
| 90 | 3301 | P40 | 4 | North-west Syria | |
| 91 | 8224 | P40 | 6 | Southern Cyprus | ICP |
| 98 | 8032 | P40 | 4 | North-west Syria | |
| 99 | 10729 | P40 | 4 | North-west Syria | |
| 100 | 14222 | P40 | 4 | North-west Syria | |
| 145 | 1242 | P30 | 1 | Haifa Bay | ICP |
| 146 | 974/975 | P31 | 2 | Northern Coastal Palestine | ICP |
| 147 | 8219 | P16 | 3a | Akkar Plain | ICP |
| 148 | 14283 | P40 | 6 | Southern Cyprus | ICP |
| 149 | 13757 | P51 | 5 | Coastal Lebanon | ICP |
| 150 | 2825 | P40 | 4 | North-west Syria | NAA/ ICP |
| 151 | 3971 | P31 | 2 | Northern Coastal Palestine | NAA/ ICP |
| 152 | 3885 | P33 | 5 | Coastal Lebanon | NAA |
| 153 | NN | P30 | 1 | Haifa Bay | NAA/ ICP |
| 154 | 13523 | P16 | 3a | Akkar Plain | ICP |
| 155 | 10780 | P30 | 1 | Haifa Bay | ICP |
| 200 | 8107 | P71 | 2 | Northern Coastal Palestine | NAA/ ICP |
| 206 | 14159 | P70 | 2 | Northern Coastal Palestine | ICP |
| 216 | 11423 | P51 | 5 | Coastal Lebanon | ICP |
| 217 | 3005 | P51 | 5 | Coastal Lebanon | ICP |
| 218 | 11615 | P70 | 2 | Northern Coastal Palestine | ICP |
| 220 | 11542 | P33 | 5 | Coastal Lebanon | ICP |
| 221 | 13772 | P40 | 6 | Southern Cyprus | ICP |
| 224 | 3004 | P51 | 5 | Coastal Lebanon | NAA/ ICP |
| 225 | 8058 | P51 | 5 | Coastal Lebanon | NAA |
| 245 | 5320 | P16 | 3b | Akkar Plain | NAA/ ICP |
| 246 | 3968 | P16 | 3a | Akkar Plain | NAA/ ICP |
| 247 | 2391 | P16 | 3a | Akkar Plain | NAA/ ICP |
| 248 | 3969 | P16 | 3b | Akkar Plain | NAA/ ICP |
| 249 | 5322 | P16 | 3b | Akkar Plain | NAA/ ICP |
| 251 | 2532 | P33 | 5 | Coastal Lebanon | NAA/ ICP |
| 252 | 2530 | P31 | 2 | Northern Coastal Palestine | NAA |

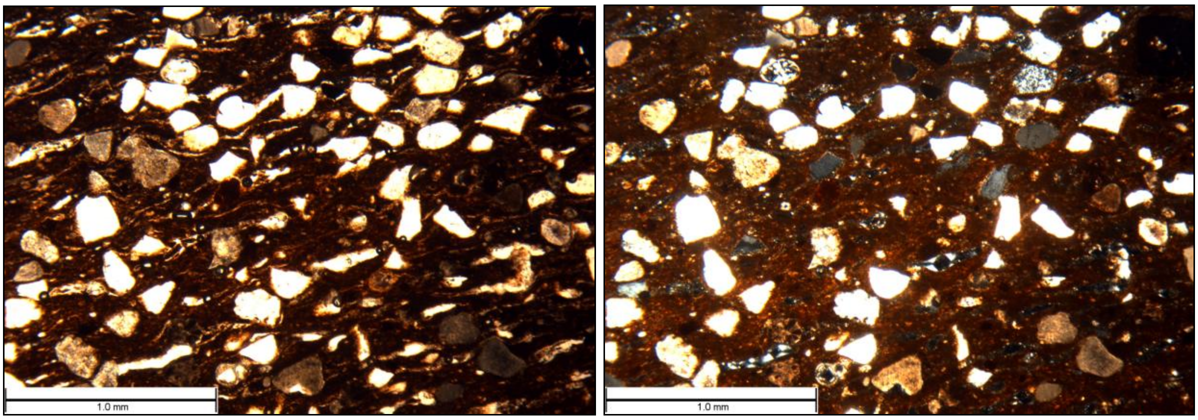
### 7.2.1 LBA Group 1 ("Haifa Bay")

#### 7.2.1.1 Summary

This group consisted of samples produced from *Hamra* clay[188] and inclusions of quartz, bioclasts (including *Amphiroa* algae clasts), limestone, chalk, and chert (Fig. 7.3; Bourriau *et al*. 2001: 116-121, 140; Smith *et al*. 2004: 56-58). Less common components are weathered basalt fragments, feldspars and some heavy minerals. The sizes of the quartz and bioclasts are both between fine and medium, and their relative amounts are similar[189]. Both constituents are rounded and well sorted in the matrix. The inclusion types indicate that coastal sand was used as a temper. Based on the intact limestone and optical activity of the matrix, most of the samples were fired between 700°C and 800°C.

Coastal sand with equivalent amounts of quartz and bioclasts, and volcanic rock fragments, is found in Haifa Bay in northern Palestine. Here the sands contain quartz from the Nile that was carried northwards by currents (Sivan *et al*. 1999: 283). This phenomenon creates rounded grains and similar frequencies of quartz and bioclasts for the sand deposited in Haifa Bay. The weathered basalt fragments originate from Eocene volcanic outcrops along the Jezreel Valley, which is drained by the Qishon River that empties into Haifa Bay (Sneh *et al*. 1998a). Tell Abu Hawam, a port from ca. 1450 BC, or possibly earlier, until around ca. 1200 BC, is a likely location for the production of the jars (Fig. 7.1; Artzy 2007). Akko was also inhabited in this period and was mentioned in the archive at Ugarit, suggesting that it was a part of the Eastern Mediterranean trade network (Heltzer 1978: 151; Dothan 1993).

Fig. 7.3: Photomicrographs of Group 1 thin section, 40x magnification, note equivalent amount of white quartz and gray bioclasts

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[188] See Chapter 5 for clay terminology.
[189] See Appendix I for definitions of terms used.

#### 7.2.1.2 Results

Some MBA Canaanite jars (Group 4) also appear to have been produced in this region (Fig. 7.2). Comparison was made between thirteen MBA samples and nine LBA samples. However, the provenance assignments were not identical, as the MBA samples had been assigned to the region from Akko south to Jaffa, while the Group 1 LBA samples were suggested to derive only from Haifa Bay. Nevertheless, four of the nine LBA samples had similar sand temper to some of the MBA samples. The most obvious difference was the clay, as the MBA jars were typically made of rendzina, while the LBA jars were produced from the more iron-rich *Hamra*. Weathered basalts as seen in the LBA jars were absent from the MBA examples. In this region, the characteristics of the coastal sand are the best identifier for provenance, as *Hamra* and rendzina are widely distributed in Palestine (Dan *et al*. 1975). Therefore, the similarities in temper between the two sets of jars suggests that transport jars were probably produced in this part of northern Palestine in both the MBA and LBA, but that a change in clay resource utilization occurred between the two periods.

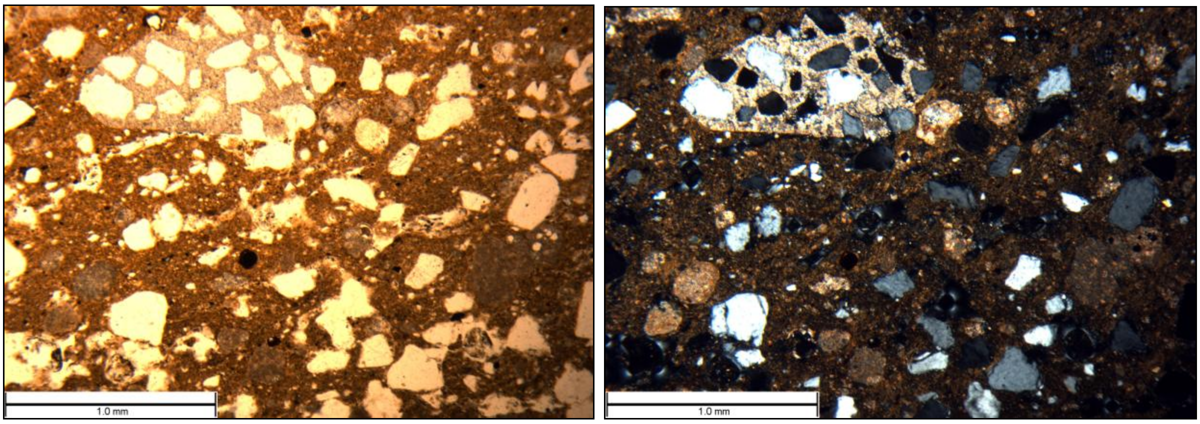
### 7.2.2 LBA Group 2 ("Northern Coastal Palestine")

#### 7.2.2.1 Summary

The samples in Group 2 appear similar to those in LBA Group 1, but contain fewer basalt fragments and have a greater amount of quartz (Fig. 7.4; Bourriau *et al*. 2001: 121-125, 140; Smith *et al*. 2004: 58, 60, 63-64). The clay is typically *Hamra*, although some samples appear made of rendzina. Other inclusions are bioclasts, chalk, kurkar, feldspars, and chert. Inclusions of quartz, bioclasts, and limestone are typically coarse-sized and rounded, however, the quartz grains are the most common. The sorting is usually poor. The *Hamra* clay does not appear to have been altered before the sand temper was added, however, the rendzina clays do appear slightly refined either by the potter or through the selection of clays in which natural processes had removed larger inclusions. Some of the samples made with rendzina were also mixed with *Terra Rossa*. The firing temperature was not above 800°C, except for three samples where the limestone was beginning to decompose (TS# 79, TS# 151, and TS# 252).

The abundant, large quartz grains and infrequent bioclast inclusions suggest that the location of production of these jars was along the central to northern coast of Palestine (Fig. 7.1; Emery & Neev 1960: 6-7, 10-11). The quartz size and amount drops as the grains are carried by the currents from south to north resulting in beach sand in the central coast containing larger and more common quartz grains than the sand further north. Furthermore, the lack of *Amphiroa* algae clasts in most samples and the presence of kurkar also indicate the central coastal area, as kurkar ridges are common in this area and the sands there lack *Amphiroa* clasts (Buchbinder 1975: 45-46; Sneh *et al*. 1998a). *Hamra*, rendzina, and *Terra Rossa* are widely distributed in this area (Dan *et al*. 1975). Several sites were notable during the LBA in this region such as Jaffa, an Egyptian administrative centre, Tel Dor, and Tel Nami East (Artzy 1993; Kaplan and Ritter-Kaplan 1993; Stern 1993).

Fig. 7.4: Photomicrographs of Group 2 thin section, 40x magnification, note kurkar grain in upper left

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7.2.2.2 Results

The suggested provenance for LBA Group 2 is similar to that purposed for the MBA Group 4 vessels (Fig. 7.2). The Group 4 samples had already been compared to the LBA Group 1 samples that had been assigned to a more restricted area. Since the interpreted provenance for MBA Group 4 also included the area designated for LBA Group 2, thirteen MBA samples were compared to seven LBA samples. Three of the LBA examples were similar to the MBA samples in terms of the coastal sand temper and utilization of rendzina. Only some of the LBA samples were produced of this material, while all of the MBA examples were made of rendzina. As the coastal sand temper is diagnostic for provenance, the similarities in quartz and bioclast amounts between the MBA and LBA samples suggest that jars were probably produced in this region during both periods (Emery & Neev 1960: 6-7, 10-11). However, there appears again to have been a change in the clay materials employed for the production of the LBA jars.

### 7.2.3 LBA Group 3 ("Akkar Plain")

#### 7.2.3.1 Summary

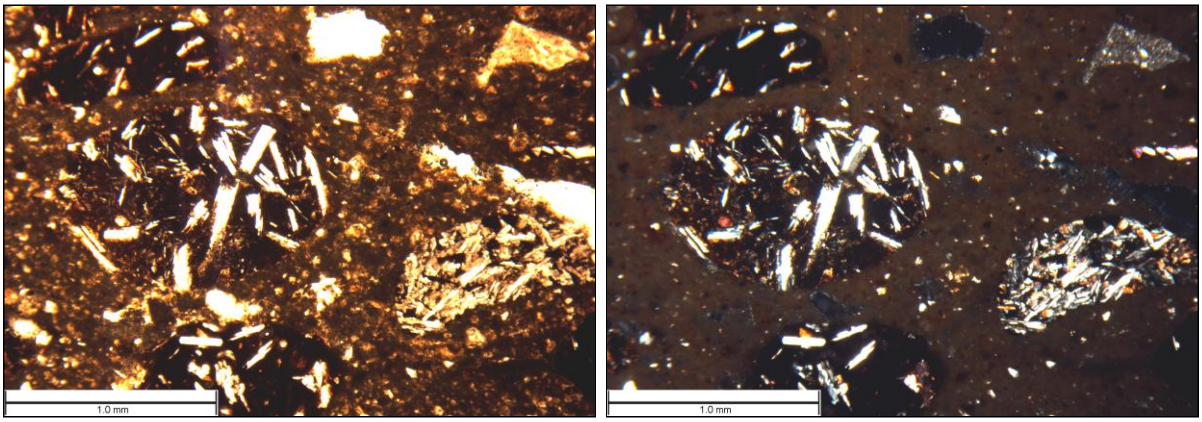
The Group 3 samples are made from either a Neogene marl clay, Group 3a, or a more calacareous clay, Group 3b (Fig. 7.5; Bourriau *et al*. 2001: 125-127, 141; Smith *et al*. 2004: 61, 64-65)[190]. Some of the samples of Neogene clay also contained *Terra Rossa*. For both groups, the dominant inclusions are hypocrystalline alkali olivine basalt showing various degrees of weathering. Other constituents are limestone, chalk, quartz, chert, and lesser amounts of chalcedony, geode quartz (chalcedonic quartz), serpentine, and rare bioclasts. The very fine to coarse-sized basalt fragments are typically rounded, as are the similarly sized limestone inclusions, while the quartz grains are very fine to medium and subangular. The rare chert grains are typically angular to subangular and of fine to medium-size. The rounded shape of the basalt inclusions suggests a riverine origin. The more angular chert grains, if from the river, entered the system much closer to where the sand was collected. For some samples, *Terra Rossa* was also added probably to make the clay more malleable. The firing temperature for the Group 3a samples was between 700°C and 800°C, while the Group 3b samples had been fired to higher temperatures.

Neogene marl clay is found only along the coast of Lebanon in limited exposures (Beydoun 1977: 333-335). However, the lack of coastal material in most of the samples suggests a more inland area where volcanic outcrops are found. This description fits the area of the Akkar Plain where the Nahr el-Kebir drains a volcanic and sedimentary region, and Neogene marls are available (Fig. 7.1; Dubertret 1974: 383-386; Beydoun 1976: 321). The difference in weathering of the basalt inclusions relates to different volcanic flows of the same geological age that have been exposed for varying lengths of time. The similarity of Group 3a samples to the Amarna Letters sent from the site of Irqata (Tell 'Arqa, see Goren *et al*. 2004: 108, 114, 189-190) suggests this site may have produced some of the vessels. The samples in Group 3b, although undoubtedly also from the Akkar Plain, may have been produced at a different site, or the potters may have selected a different clay. A site that became prominent in the Akkar Plain in the LBA was Tell Kazel (Sumur), which was an Egyptian administrative centre (Badre *et al*. 1994: 310-346; Badre & Gubel 1999-2000: 136-179, 197-200). The petrographic analysis of locally made LBA Mycenaean ceramics at Tell Kazel revealed a fabric consisting of igneous rock fragments, chert, quartz, and limestone (Badre *et al*. 2005: 20-23). This description and the images appear similar to the LBA

[190] The clay differences are not related to chronological changes as both can appear in the same levels.

Canaanite jars, a fact noted by the petrographer (Badre *et al*. 2005: 23, note 34). Further, similar clay and inclusions were identified in the Amarna Letters sent from Sumur (Goren *et al*. 2003: 7-8; Goren *et al*. 2004: 109-111). The identified Quaternary coastal clay for these tablets may be similar to the calcareous clay for the Group 3b samples.

Fig. 7.5: Photomicrographs of Group 3b thin section, 40x magnification, note black basalt inclusions

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7.2.3.2 Results

Both LBA Group 3a and 3b samples were compared to the seven samples from MBA Group 1 assigned to the Akkar Plain. Of the twelve LBA samples, six from Group 3a were comparable to the MBA examples, whereas the Group 3b samples were different in clay type. The addition of *Terra Rossa* to the clay was a feature of vessel manufacture in both periods, but was more noticeable in the LBA examples. The type of basalt and the presence of some more weathered examples were similar between the two fabric groups. However, the LBA samples had smaller and more abundant basalt inclusions, while the MBA examples had fewer and large fragments. The chert and limestone inclusions were also larger in the MBA samples. The LBA jars lack these features. Therefore, while workshops in the Akkar Plain appear to continue to produce and export Canaanite jars to Egypt, the utilization of materials seems to change, and possibly additional sites began to manufacture jars in the LBA.

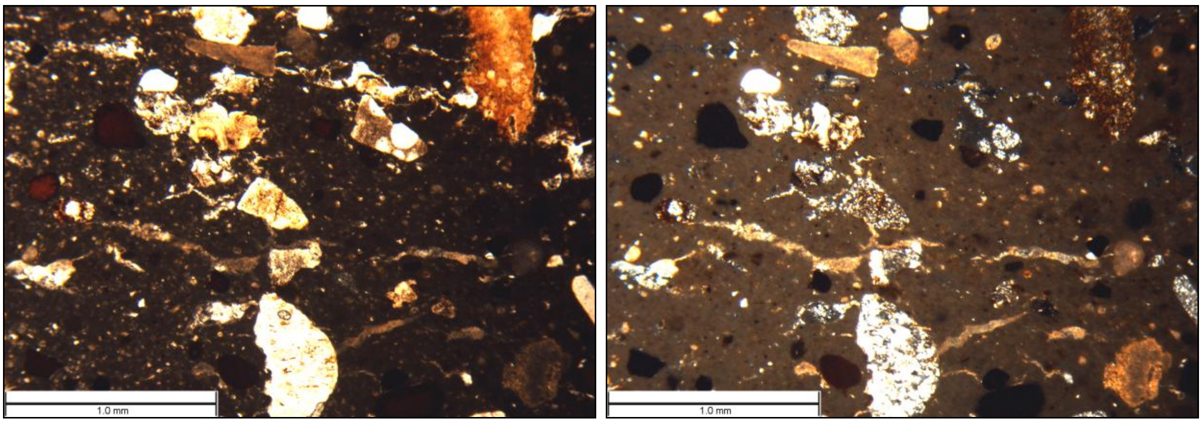
### 7.2.4 LBA Group 4 ("North-west Syria")

7.2.4.1 Summary

Samples in Group 4 contain altering volcanic rock fragments, iron-stained radiolarian chert, and limestone in a marl clay matrix (Fig. 7.6; Bourriau *et al*. 2001: 127-132, 142-143; Smith *et al*. 2004: 61-62, 65-66). Other inclusions consist of quartz, replacement chert (same as “chert” described in the other groups), chalcedony, and serpentine. The size of the quartz, limestone, and replacement chert are typically from very fine to coarse and most are subangular to rounded. Their sorting is moderate to poor. The inclusions suggest the addition of temper containing volcanic and sedimentary inclusions. Further, the rounded radiolarian and replacement chert indicate an origin for the materials from a river or other water source. One sample had a few bioclasts, including *Amphiroa* species algae clasts, possibly indicating a source near the coast. Two samples (TS# 98 and TS# 99) were fired to temperatures above 850°C, while the other three samples (TS# 90, TS# 100, and TS# 150) were fired at lower temperatures.

The radiolarian chert fragments and the altering volcanic inclusions indicate an origin for these samples in an ophiolite complex where oceanic crust was lifted onto continental crust (Whitechurch *et al*. 1984). While ophiolite complexes are found in north-western Syria, southern Turkey, and southern Cyprus, the prevalence of iron-stained radiolarian chert suggests that Syria is more likely the location of production (Fig. 7.1). Comparison with thin section samples of lamps from Ras Shamra (Ugarit) and Amarna Letters sent from this site further support this location as the provenance of the jars (Smith *et al*. 2000; Goren *et al*. 2004: 88-90, 186; Smith *et al*. 2004: 61). Chemical data from Syrian and Cypriot comparative material also indicated Syria was the likely region of manufacture. Ugarit was a large LBA trading centre, so its involvement in the export of commodities in Canaanite jars is not surprising (Yon 2006).

Fig. 7.6: Photomicrographs of Group 4 thin section, 40x magnification, note iron-stained radiolarian chert at top right

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#### 7.2.4.2 Results

As none of the MBA samples featured inclusions indicative of an ophiolite complex, no comparative analysis was performed with the five LBA samples.

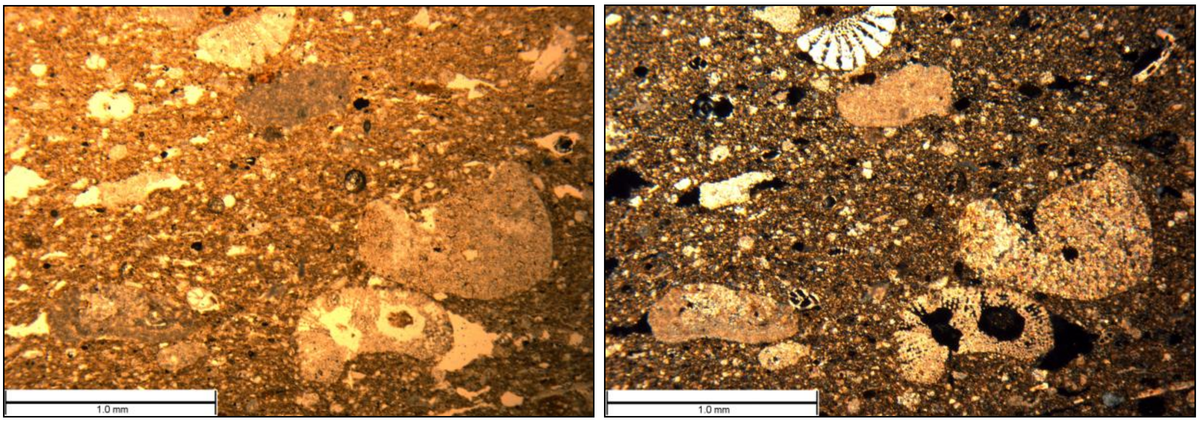
### 7.2.5 LBA Group 5 ("Coastal Lebanon")

#### 7.2.5.1 Summary

Group 5 samples were produced from a rendzina typically mixed with *Terra Rossa*. The inclusions comprised mostly bioclasts, including many *Amphiroa* algae clasts, with lesser amounts of limestone, chalk, quartz, chert, chalcedony, and geode quartz (Fig. 7.7; Bourriau *et al*. 2001: 132-135, 143; Smith *et al*. 2004: 62-63, 71, 73). Both the limestone and quartz inclusions were rounded and present in sizes very fine to coarse. The sorting is poor to moderate. The clay appears to lack very large natural inclusions suggesting either the intentional selection of a naturally refined clay or the clay was refined during processing. The samples were fired below 850°C.

The presence of abundant bioclast inclusions, particularly of the *Amphiroa* species, indicates that the jars were probably produced along the coast of Lebanon (Fig. 7.1; Dubertret 1962; Buchbinder 1975: 45-46). Beach sands in this region are dominated by bioclasts with prevalent *Amphiroa* clasts and lesser amounts of quartz, geode quartz, chalcedony, and chert grains. The latter derive from the Senonian or Eocene and Cenomanian-Turonian age sedimentary outcrops in the Lebanese mountains (Dubertret 1974: 376, 378, 1966: 308-309; Saint-Marc 1974: 201-202; Beydoun 1977: 322, 329, 332-333). The variability in the samples suggests several sites, such as the large city-states of Beruit, Sidon and Tyre, may have produced Canaanite jars (Bikai 1978: 43-50, 72-73; Badre 1997; Doumet-Serhal 2008).

Fig. 7.7: Photomicrographs of Group 5 thin section, 40x magnification, note bioclast inclusions

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#### 7.2.5.2 Results

Comparison of the twenty-one MBA samples (Group 3) assigned to coastal Lebanon to the eleven LBA samples revealed ten that were similar. The utilization of rendzina was analogous and the components of the coastal sand were in most cases similar. Differences appeared in the prevalence of *Terra Rossa* and the more refined rendzina clay for the LBA samples. The subgroup of MBA samples with the most bioclast inclusions (Ownby 49, 53, and 56) appeared closest to the LBA samples, while the remaining MBA examples had fewer bioclasts, including fewer *Amphiroa* algae clasts. Thus, although sites on the coast of Lebanon probably produced Canaanite jars for export in both periods, the production technology changed in the LBA. While these are chronological differences, there may have been further changes related to the movement of site(s) of production and/or the workshops producing the vessels. Nevertheless, comparability in coastal sand temper implies that some sites were probably manufacturing vessels in both periods.

### 7.2.6 LBA Group 6 ("Southern Cyprus")

#### 7.2.6.1 Summary

The samples in Group 6 featured a calcareous or iron-rich clay with the same set of inclusions of spillites[191], plagiogranite[192], serpentine, replacement chert, feldspars (plagioclase and alkali feldspars) and limestone (Fig. 7.8; Smith *et al*. 2004: 67-70). These inclusions are usually fine to coarse in size and most are subangular to subrounded. The sorting is poor. For the calcareous clay samples, the angular shape of the inclusions suggests they may have derived near an eroding outcrop or from riverine sand that was not far from the original rocks. Both the clay and inclusions could have come from the same secondary deposit. The same is true for most of the iron-rich clay samples, although one sample included bioclasts suggestive of a source near the coast. The firing temperature appeared to vary between 800°C and 900°C.

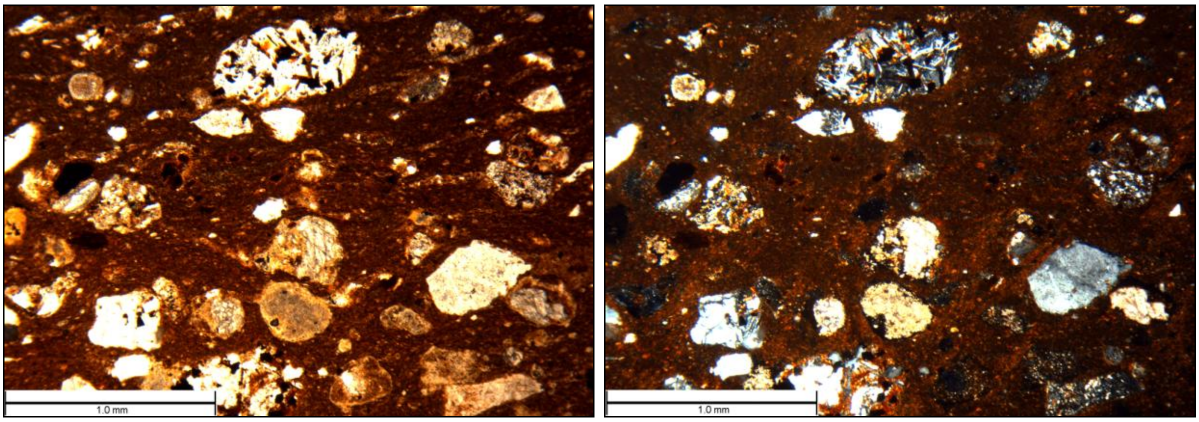
The combination of metamorphic, volcanic, and sedimentary inclusions suggests that the raw materials originated from an ophiolite complex, but one in which some of the rocks had become metamorphosed. Further, the ophiolite complex lacked radiolarian chert. Geology of this type is consistent with the Troodos complex in southern Cyprus comprising an ophiolite sequence and metamorphic rocks in the Mamonia complex (Fig. 7.1; Gass *et al*.

[191] A low grade metamorphic rock composed of albite, chlorite, actinolite, sphene, and calcite (Allaby and Allaby 2003: 512).

[192] A type of granodiorite, a coarse-grained igneous rock, composed of mostly quartz, plagioclase, biotite, and hornblende (Allaby and Allaby 2003: 241).

1994). Comparison to samples from the prominent LBA sites of Sanidha, Kalavasos-*Ayios Dhimitrios*, and Enkomi showed similarities and differences in the types and/or amounts of inclusions. Comparison to locally produced Canaanite jars from Maa-*Palaeokastro* and Hala Sultan Tekke may assist in refining the provenance of these samples (Hadjicosti 1988; Jones & Vaughn 1988; Åström 1991a and b).

Fig. 7.8: Photomicrographs of Group 6 thin section, 40x magnification, note basalt grain at top centre



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#### 7.2.6.2 Results

The examination of the MBA Canaanite jars had not identified any samples with these characteristic inclusions, therefore comparison to the six LBA samples was not carried out.

## *7.3 Compositional Comparison Results*

The LBA Canaanite jar compositional data were initially examined alone to identify sample outliers and examine any existing patterns in the data before being pooled with the MBA data. While, the LBA ICP and NAA data had been successfully combined for joint statistical analysis, this was not the case for the MBA ICP and NAA data. Therefore, the LBA data sets were examined separately. The same four statistical tests were employed, i.e. Principal Components Analysis (PCA), Hierarchical Cluster Analysis (HCA), Discriminant Analysis (DA), and K-means Cluster Analysis (KCA). As with the previous statistical analyses, the statistical tests were first run with all of the elements and samples included. Then a second run was performed with problematic elements and sample outliers removed. If samples were recognized as chemically aberrant, the thin sections were checked before they were removed for the later analyses. For the second run, the samples from Group 4 ("North-west Syria") and Group 6 ("Cyprus") were removed as these samples were from areas not identified in the MBA material. Problematic elements for the NAA data had already been noted by Al-Dayel (1995: 88-91), i.e. Cs, K, Mn, Rb, Ta, and Yb[193]. Furthermore, three samples had been analyzed twice allowing the utility of the data to be assessed through the placement of these samples together by statistical tests. For the ICP data, certain elements were removed because they were either mobile (Na, P), incompletely dissolved (Zr), or near the detection limit for the instrument (Eu, Sm, and Yb)[194]. Only TS#151 was identified as an outlier due to an atypically high concentration of Mn (Smith pers. comm.). All of the elemental concentrations were transformed into base 10 logarithms prior to statistical analyses. For the tests and graphical representation the samples were assigned to their petrographic groups, i.e. Group 1 = "Haifa Bay", Group 2 = "Northern Coastal Palestine", Group 3 = "Akkar Plain", Group 4 = "North-west Syria", Group 5 = "Coastal Lebanon", and Group 6 = "Southern Cyprus".

### 7.3.1 LBA ICP data

The first PCA of the LBA ICP data included all the elemental data and samples. The results showed a small amount of clustering of the groups deriving from the Levantine coast (Groups 1, 2, and 5) versus those with basalt inclusions (Groups 3, 4, and 6) (Fig. 7.9). Although TS#151 was separated and had previously been identified as aberrant, petrographically the sample was not different from the other samples in Group 2. The three PCs accounted for 59% of the variability, suggesting removal of problematic elements may clarify the results (Table 7.3). The second run excluded sample TS# 151 and the samples assigned to "North-west Syria" (Group 4) and "Southern Cyprus" (Group 6), along with the elements Eu, Na, Sm, Yb, and Zr. The results showed an improved separation of the samples containing basalts (Group 3) from the coastal samples, for which Group 1 ("Haifa Bay") was distinct from Groups 2 ("Northern Coastal Palestine") and 5 ("Coastal Lebanon) (Fig. 7.10). The lack of separation for Groups 2 and 5 is probably due to the rendzina employed to produce jars in both areas. Increased variability was accounted for during this run, 73%, while some of the same elements important in the first run were also significant for the second (Table 7.4).

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[193] The mobile element P was removed for all statistical tests (Freestone *et al.* 1985).

[194] These elements had been identified in the preliminary write-up of the statistical analyses of the LBA Canaanite jar data provided by L. Smith. The digestion procedure was by HF/$HClO_4$ dissolution, the 'Podmore' ceramic standard was employed to ensure accuracy and precision, and several analyses of the same sample were run to assess if inhomogenity in the samples would present difficulties in the data. Examination of the data for accuracy and precision determined that the majority of elements had performed well.

Fig. 7.9: PCA of LBA ICP Data, all elements and samples

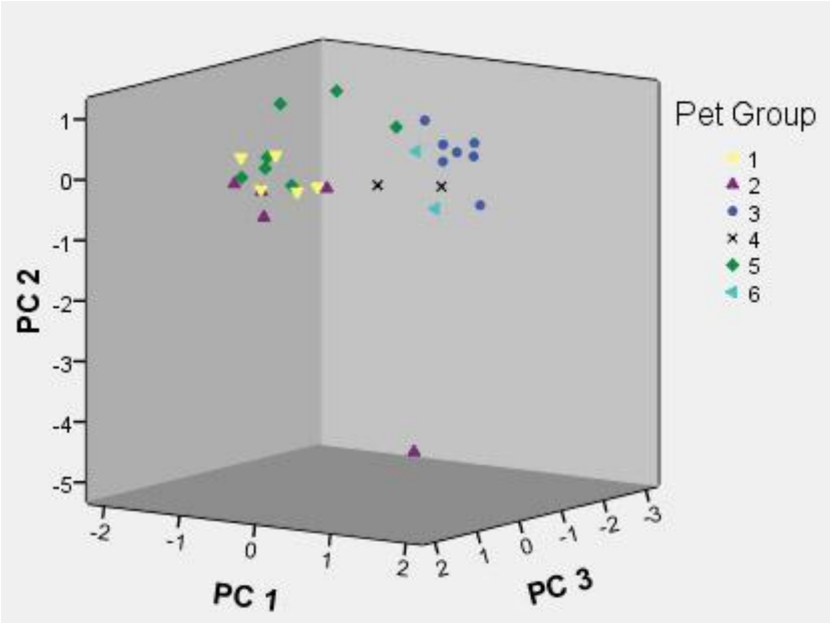



Table 7.3: Elements contributing variability to the first three components, LBA ICP data, all elements and samples

| PC 1 | PC 2 | PC 3 |
|---|---|---|
| Al, Cu, Eu, Fe, Ni, Sc, V | Ba, Dy, Li, Mn | Ce, La |

Fig. 7.10: PCA of LBA ICP Data, select elements and samples

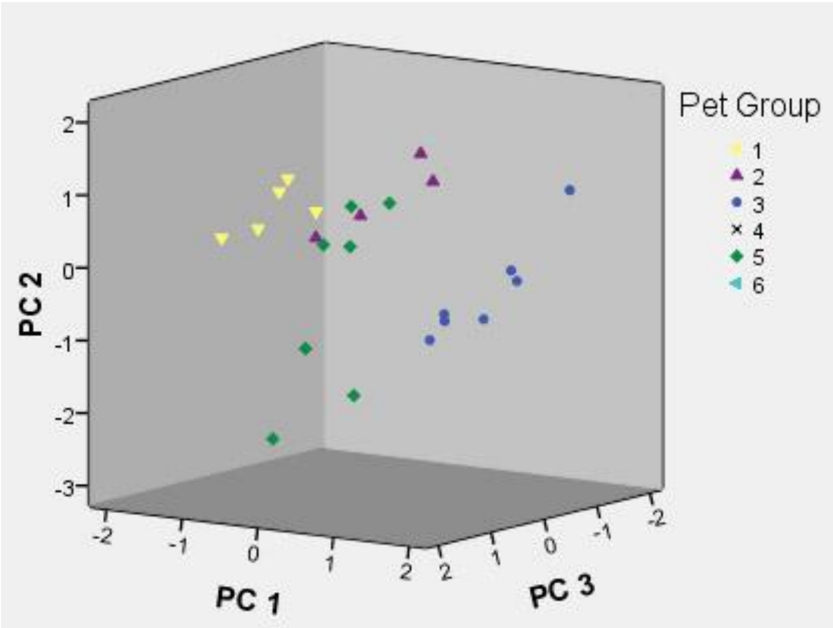


Table 7.4: Elements contributing variability to the first three components, LBA ICP data, select elements and samples

| PC 1 | PC 2 | PC 3 |
|---|---|---|
| Al, Cr, Cu, Fe, Ni, Sc, V | Ba, Ce, Dy, La | K, Mn, Ti |

The first HCA was run with all samples and elements. Two major groups were delineated, consisting of those samples with basalt and those with coastal sand (Fig. 7.11). Once again, TS# 151 was identified as an outlier. The Group 4 samples ("North-west Syria") were separated from the other basalt samples (Groups 3 and 6). The Group 1 samples ("Haifa Bay") comprised their own cluster. The mixing of samples from Groups 2 and 5 had also been noted in the PCA. The second run excluded Groups 4 and 6, sample TS# 151, and the problematic elements. The results were analogous to the first HCA with a mixed cluster of Groups 2 and 5, connected to the cluster for Group 1 (Fig. 7.12). At a greater distance, these coastal samples were linked to the cluster of Group 3 samples with basalt inclusions. The separation of Group 1 was probably due to its manufacture from *Hamra*, while Groups 2 and 5 were typically produced from rendzina.

Fig. 7.11: HCA of LBA ICP Data, all elements and samples (colour of samples related to the petrographic groups as specified for the other statistical tests)

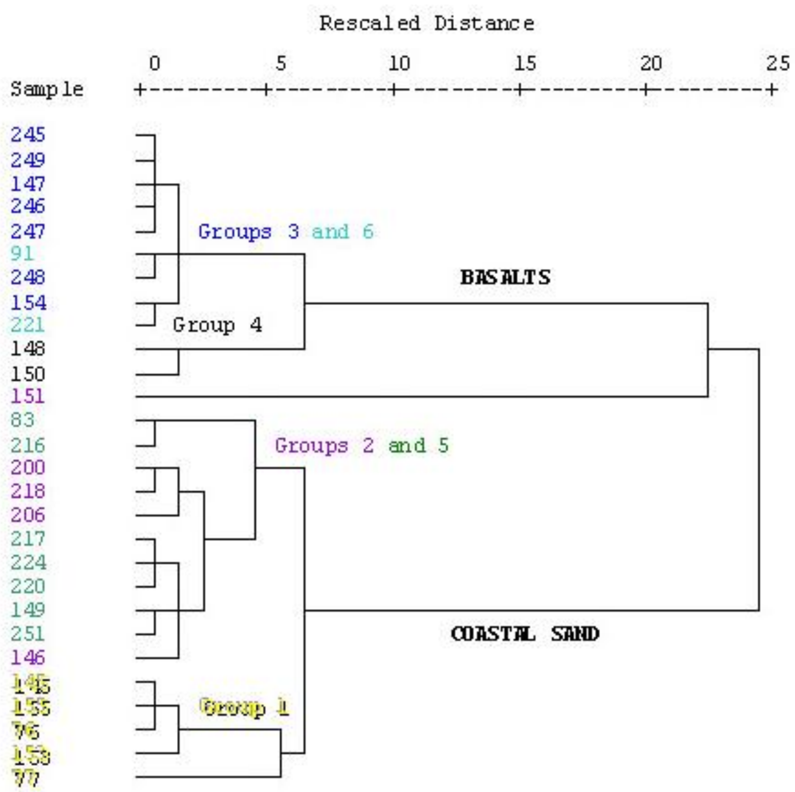
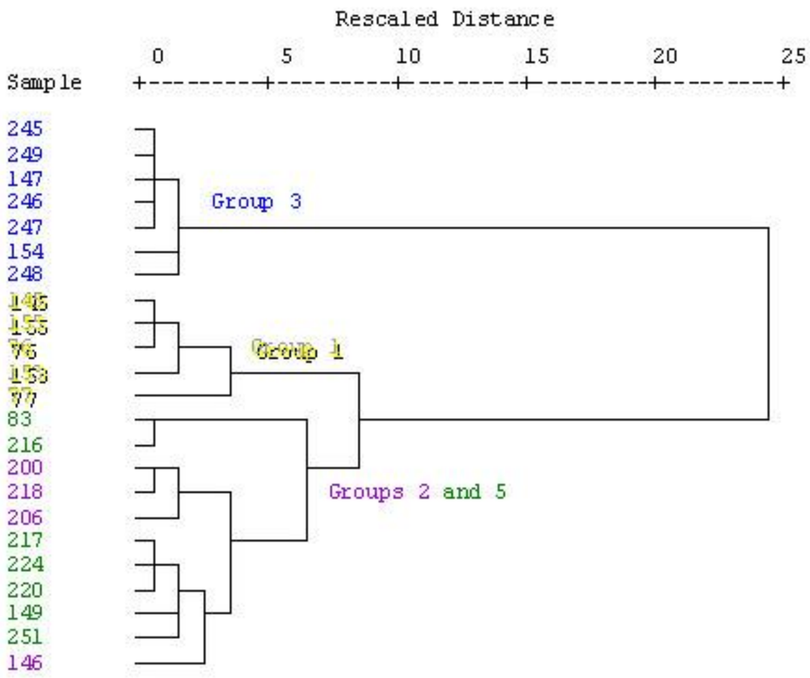


Fig. 7.12: HCA of LBA ICP Data, select elements and samples




The first DA with all the elemental data and samples revealed tight clusters based on suggested provenance (Fig. 7.13). The two samples from Group 4 ("North-west Syria") were placed at a great distance from the other groups; note the scale for the X-axis is between -100 and +100 in order for the groups to be plotted on the same graph. Removal of these samples, Group 6 ("Southern Cyprus"), and TS# 151, along with the problematic elements, still revealed tight clusters for the individual groups (Fig. 7.14). The successful separation of Group 2 ("Northern Coastal Palestine") from Group 5 ("Coastal Lebanon") was encouraging as the previous tests had shown little separation. The placement of Group 1 ("Haifa Bay") at a distance from these samples, while Group 3 ("Akkar Plain") with basalt inclusions is closer to Groups 2 and 5, reveals how chemically different the Group 1 samples are to the others.

Fig. 7.13: DA of LBA ICP Data, all elements and samples

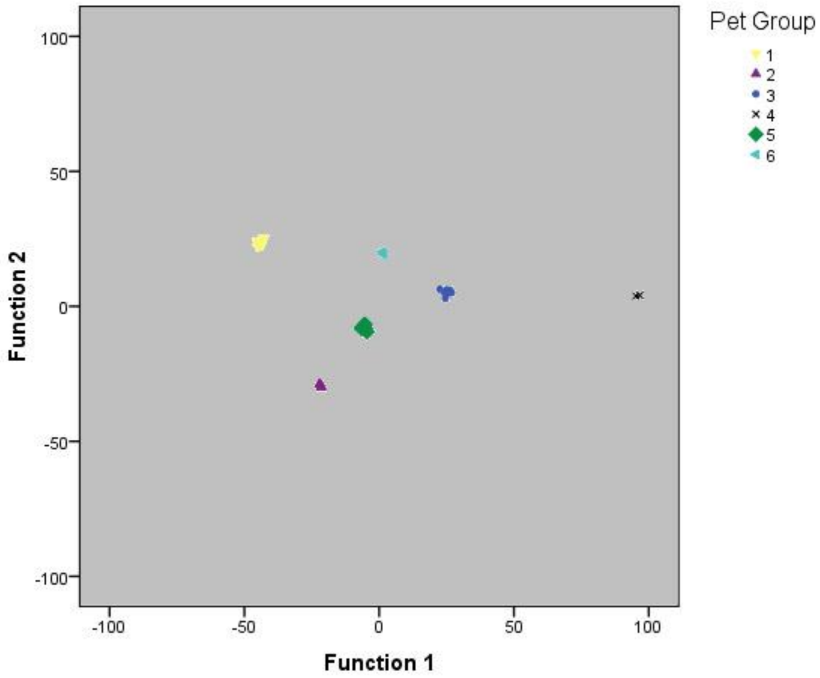
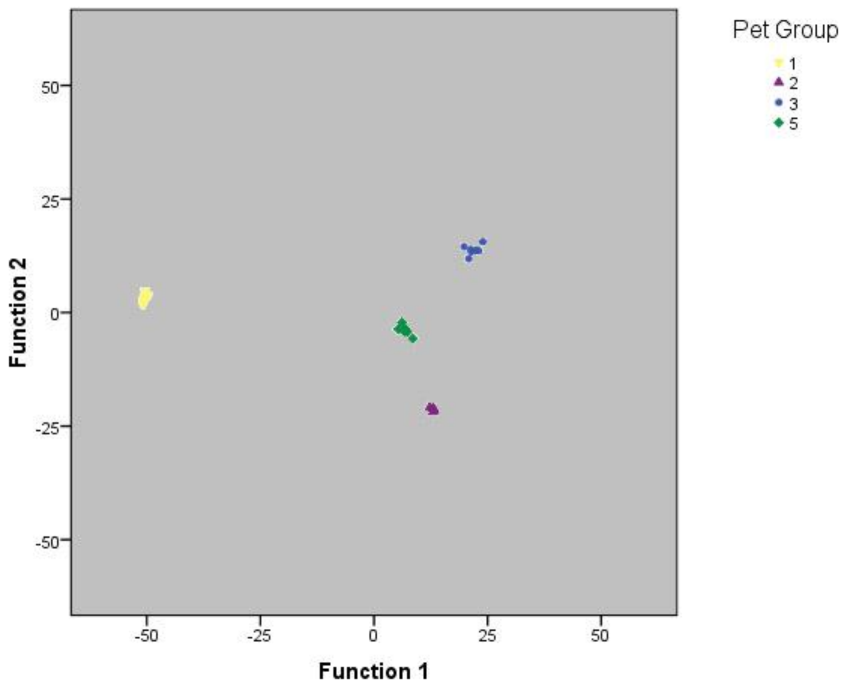



Fig. 7.14: DA of LBA ICP Data, select elements and samples



For the first KCA, six clusters were specified. The results showed that Clusters 1 and 3 contained most of the coastal Levantine samples (Groups 1, 2, and 5), while Cluster 4 was a combination of basaltic samples from the “Akkar Plain” (Group 3) and “Southern Cyprus” (Group 6) (Fig. 7.15). The two “North-west Syria” (Group 4) samples were placed in Cluster 5. Cluster 2 contained only TS# 77, while Cluster 6 had only TS# 151. TS# 77 belonged to Group 1, but in the HCA had been identified as an outlier within this group. Although this sample is not petrographically different from the others in Group 1, chemically it has a higher concentration of Co, and a lower concentration of Sm than the other samples. This may explain why it appears as an outlier. The second KCA excluded TS# 151, Groups 4 and 6, and removed the problematic elements; 4 clusters were specified. Group 1 samples were in their own cluster as were the Group 3 samples, while some mixing occurred between Groups 2 and 5, although one cluster contained only Group 5 samples (Fig. 7.16). Overall, the results of the statistical analyses support the petrographic division of the samples and revealed the data to be useful in identifying unusual samples or connections between different petrographic groups.

Fig. 7.15: KCA of LBA ICP Data, all elements and samples

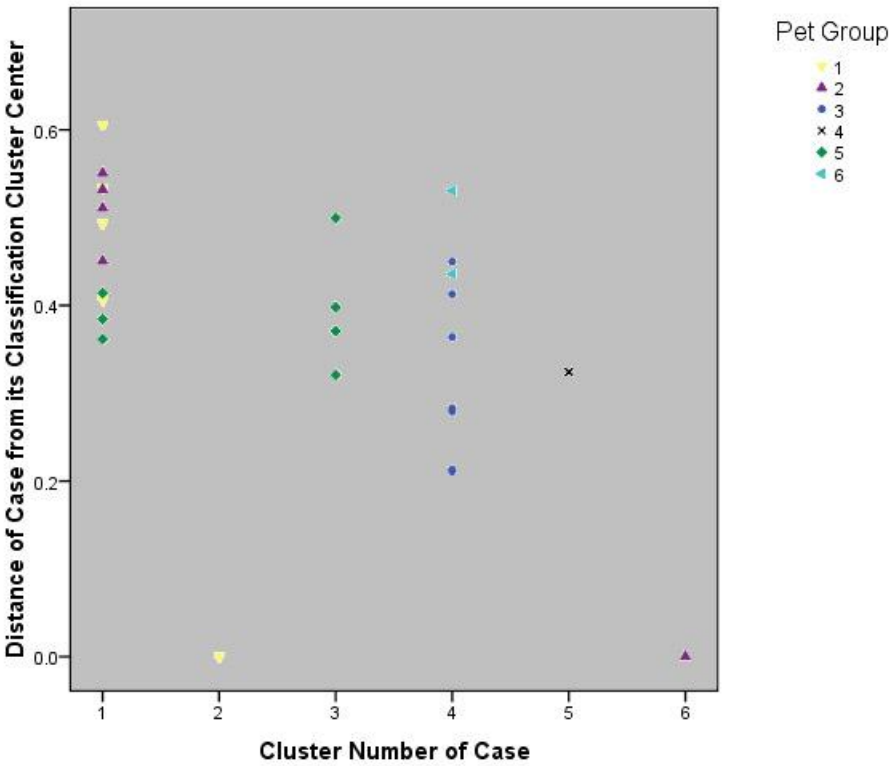
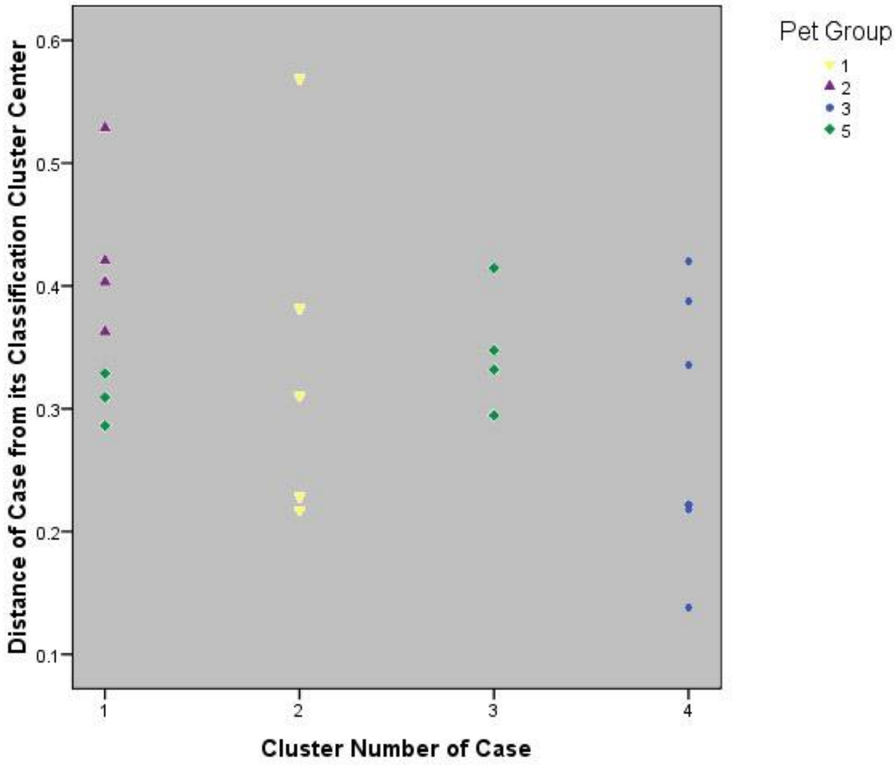


Fig. 7.16: KCA of LBA ICP Data, select elements and samples




### 7.3.2 LBA NAA data

The statistical analysis of the LBA NAA data also began with PCA. The first PCA, with all elements and samples, revealed a separation between samples with basalt inclusions (Groups 3 and 4) and those with coastal sand (Groups 1, 2, and 5) (Fig. 7.17). The first three PCs accounted for 72% of the variability based on several elements also identified in the ICP PCA (Table 7.5). A second PCA was run without the elements Cs, K, Mn, Rb, Ta, and Yb, and only the "North-west Syria" sample was removed. The results showed some slight clustering of the samples by their petrographic assignments, with the "Akkar Plain" samples (Group 3) and the "Haifa Bay" samples (Group 1) separated (Fig. 7.18). By removing the problematic elements, the three PCs now accounted for 82% of the variability, and additional elements were contributing significantly to the first PC (Table 7.6).

Fig. 7.17: PCA of LBA NAA Data, all elements and samples

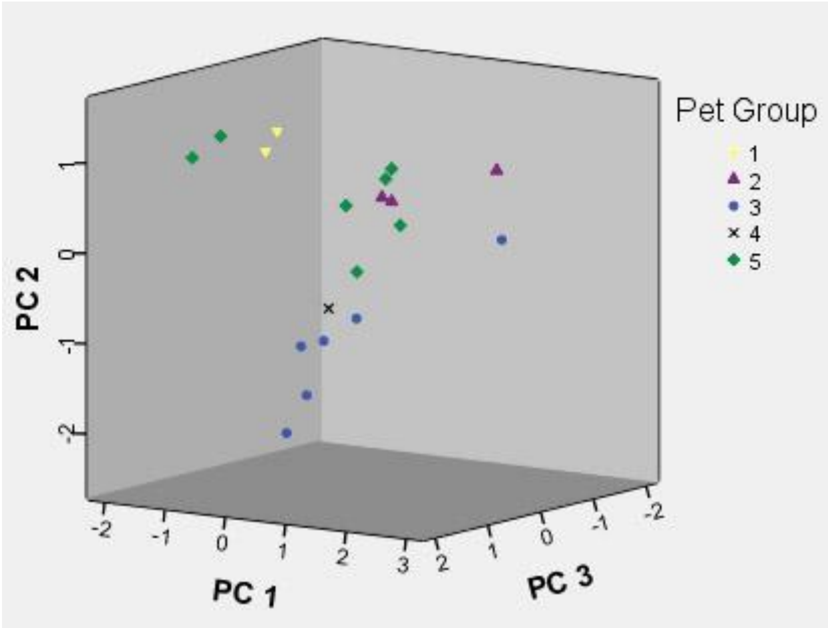



Table 7.5: Elements contributing variability to the first three components, LBA NAA data, all elements and samples

| PC 1 | PC 2 | PC 3 |
|---|---|---|
| Al, Eu, Sm, U, V | Co, Sc, Th | Cs, Rb |

Fig. 7.18: PCA of LBA NAA Data, select elements and samples

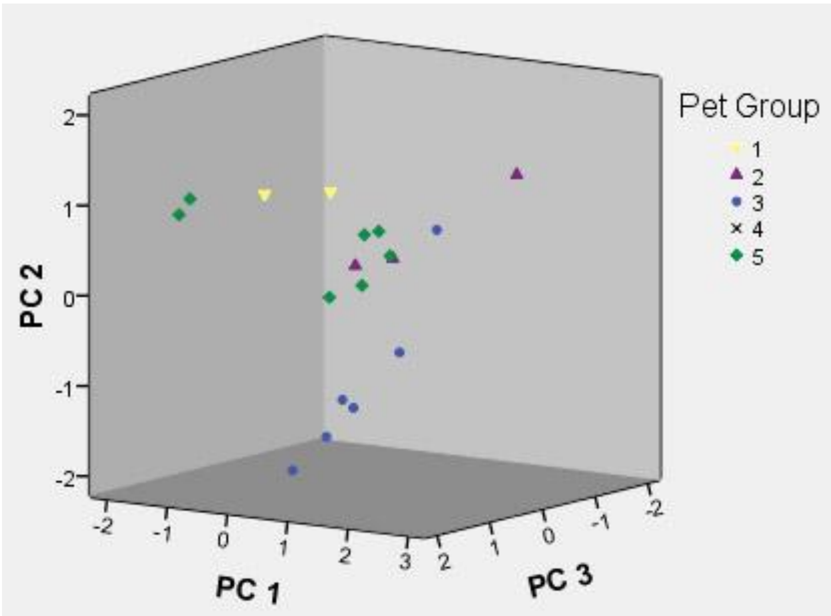


Table 7.6: Elements contributing variability to the first three components, LBA NAA data, select elements and samples

| PC 1 | PC 2 | PC 3 |
|---|---|---|
| Al, Co, Eu, Fe, Sc, Ti, U, V | Cr, La, Th | Ca |

The first HCA revealed several clusters with samples from Groups 2, 3, and 5, while the sample from Group 4 ("North-west Syria") was separate (Fig. 7.19). Additional outliers were samples TS# 248 (Group 3) and TS# 252 (Group 2), although petrographically these samples had seemed comparable to the other samples in their respective groups. A chemical similarity between the Group 1 samples and TS# 225 (Group 5, "Coastal Lebanon") was also revealed. The latter was petrographically slightly different from the other Group 5 samples, and these results may suggest it was produced closer to the proposed provenance for Group 1, i.e. "Haifa Bay". The second HCA, with the problematic elements and Group 4 sample removed, also suggested a chemical similarity between TS# 225 and Group 1 (Fig. 7.20). However, TS# 248 and TS# 252 were now better integrated with the other samples. For both tests, the repeat analyses of the same sample were placed together suggesting the data were of good quality.

Fig. 7.19: HCA of LBA NAA Data, all elements and samples

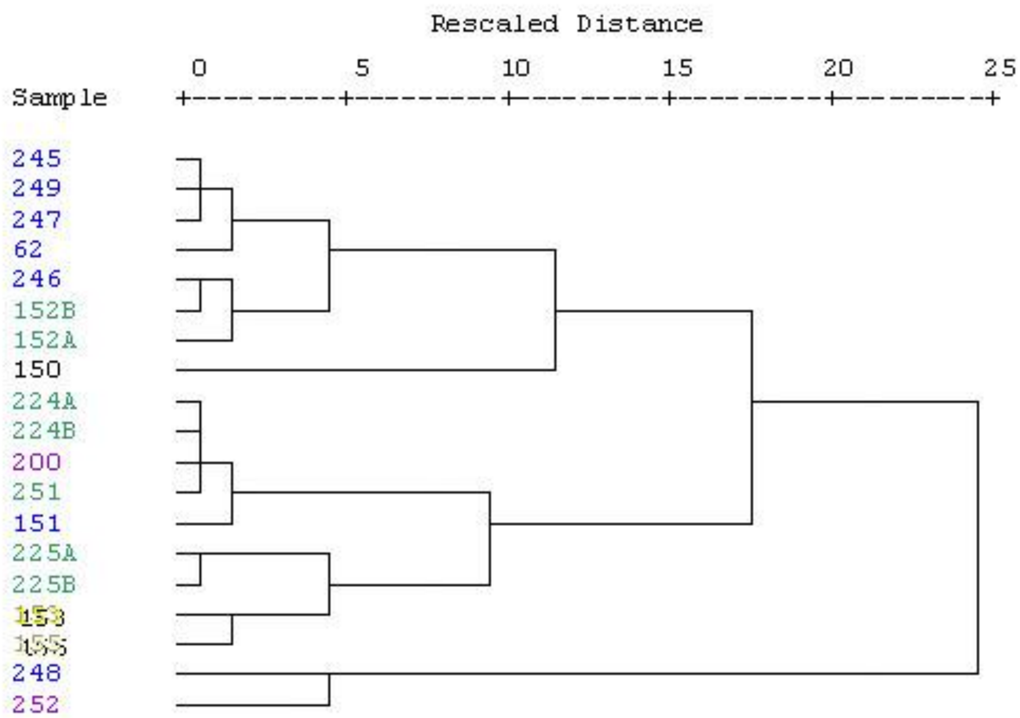
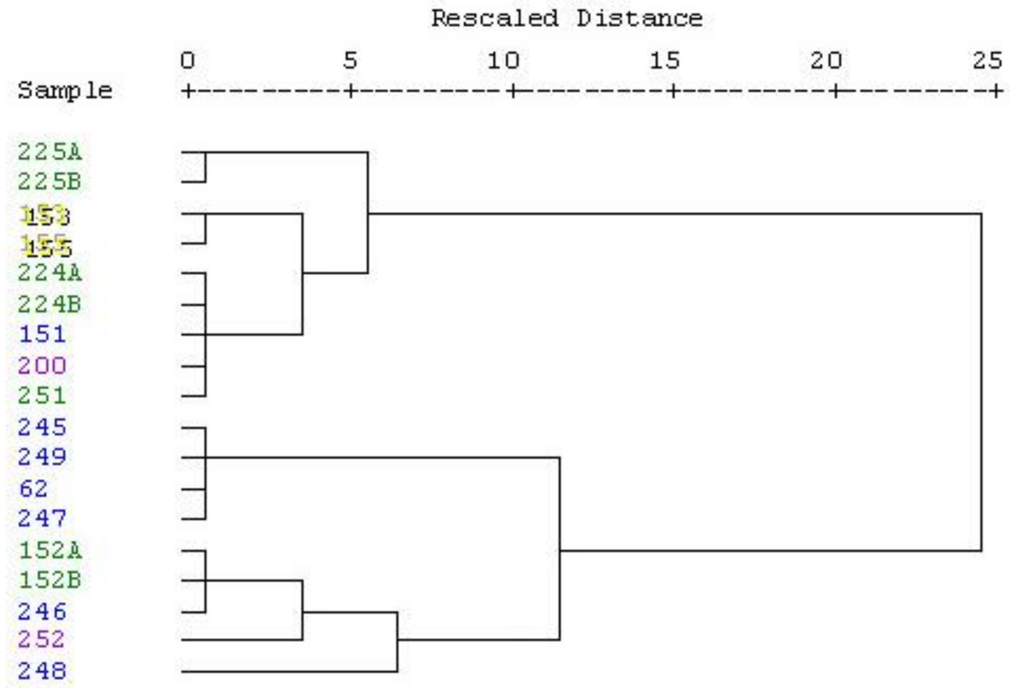


Fig. 7.20: HCA of LBA NAA Data, select elements and samples




The DA with all the elemental data and samples included revealed five very tight clusters based on their petrographic assignments (Fig. 7.21). These results highlighted the chemical difference of the Group 4 ("North-west Syria") sample, which was creating a tighter clustering of the other samples (note the scale for the X-axis is again from -100 to +100). For the second test, this sample was removed, as were the problematic elements. The results showed a much clearer clustering of the remaining samples by their petrographic groups (Fig. 7.22). As with the first DA, the Group 1 samples were separated from the two samples of TS# 225 (Group 5). The other aberrant samples were now also placed into their assigned groups. However, as this statistical test maximizes the chemical differences, the results must be assessed carefully.

Fig. 7.21: DA of LBA NAA Data, all elements and samples

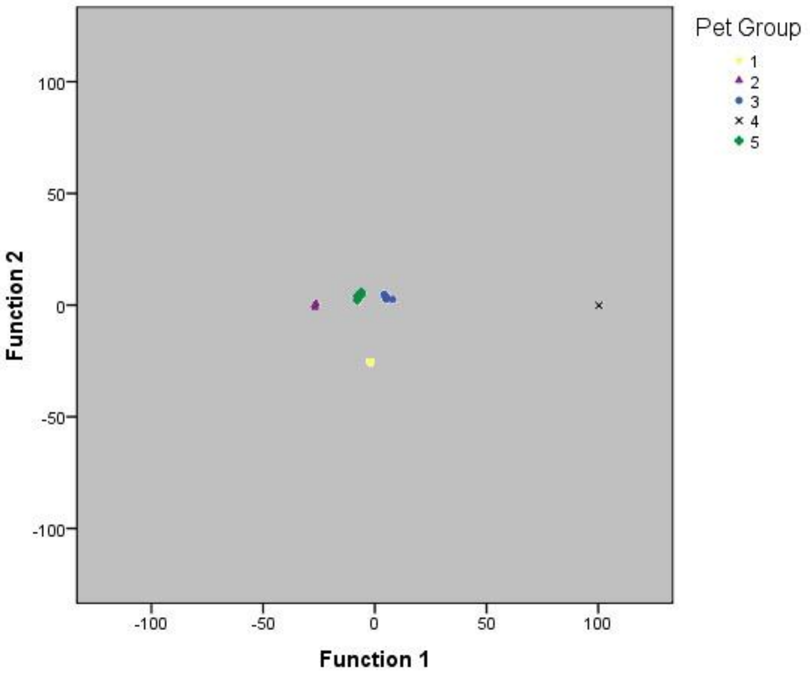
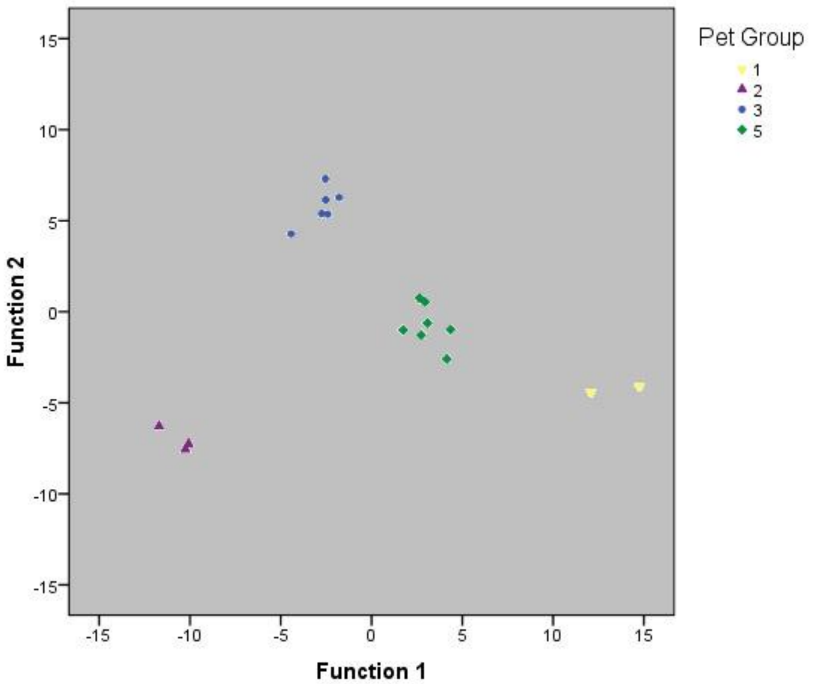



Fig. 7.22: DA of LBA NAA Data, select elements and samples



The KCA, with five groups designated and all elements and samples included, further supported the difference of the "North-west Syria" (Group 4) sample (Fig. 7.23). Moreover, the chemical similarity between TS# 225 and Group 1 was maintained, although surprisingly, one of the Group 1 samples, TS# 153, was placed away from this cluster. While most of the samples were placed in Cluster 4, Cluster 3 comprised TS# 252 and Cluster 5 held TS# 248. These samples had been noted in the HCA as different in their composition from the other samples. The second KCA was run without the Group 4 sample and problematic elements; four groups were specified. The results showed a clearer separation of the Group 3 samples assigned to the "Akkar Plain" (Fig. 7.24). However, TS# 248 was again placed into its own cluster, suggesting it was chemically different from the other Group 3 samples. Cluster 2 comprised the repeat analyses of TS# 152 and sample TS# 252. This was surprising as only the second HCA had showed any similarity between these samples. Finally, although there remained a single cluster of the majority of the samples, the separation of most of the Group 3 samples suggested removing the Group 4 sample and problematic elements improved the results.

Fig. 7.23: KCA of LBA NAA Data, all elements and samples

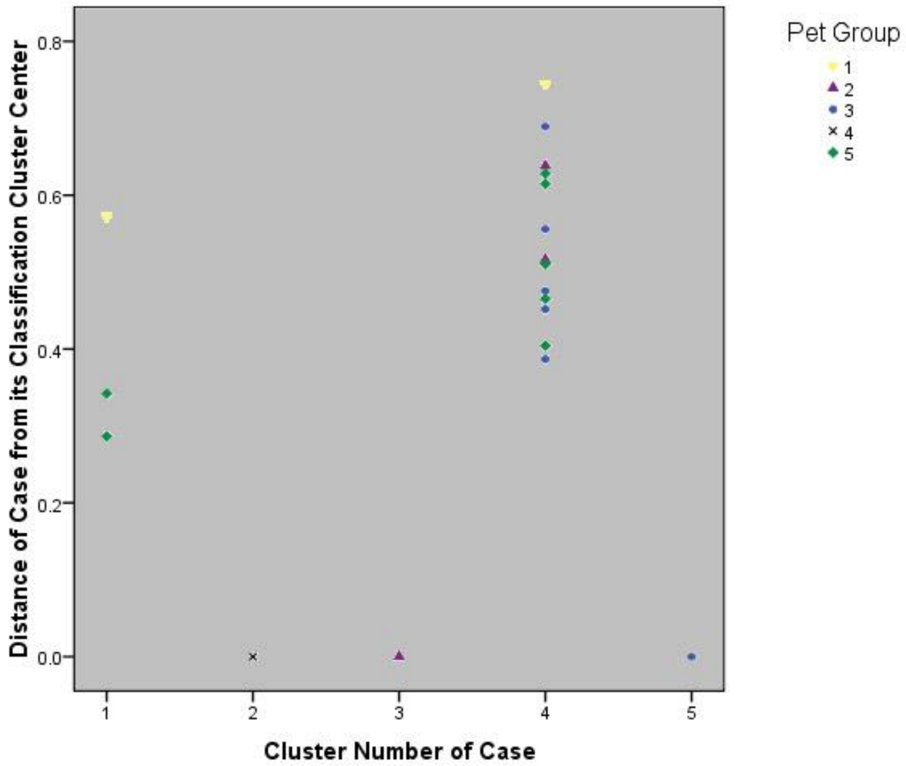
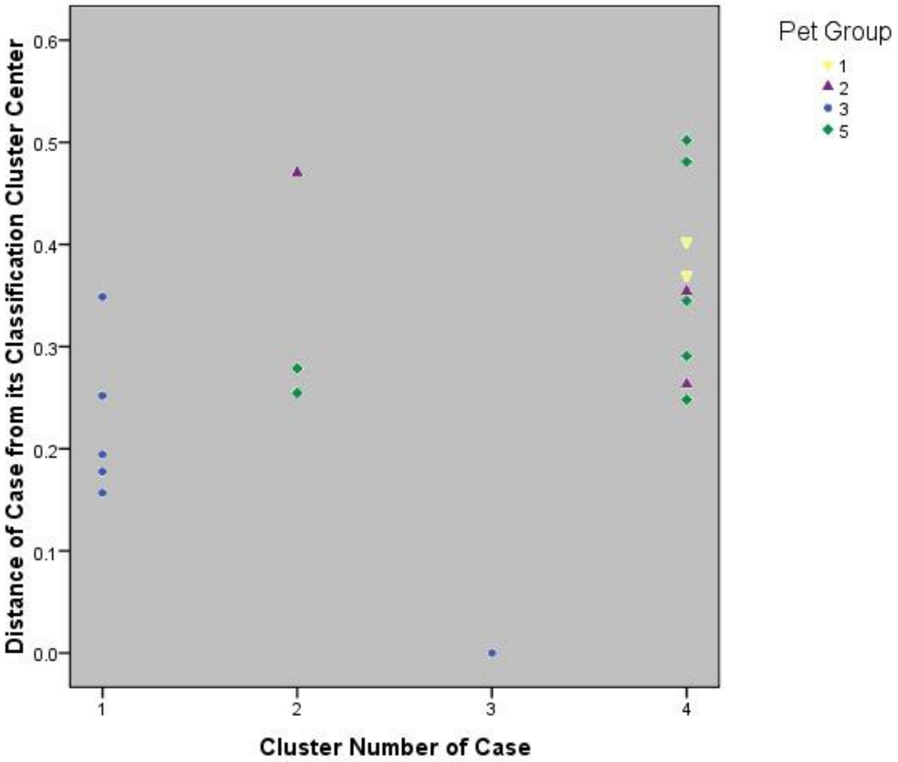


Fig. 7.24: KCA of LBA NAA Data, select elements and samples




### 7.3.3 MBA and LBA compositional data

The petrographic comparison of thin sections from the MBA and LBA Canaanite jars had suggested that some similarities existed that might be clarified by the compositional data. For analysis, the samples were placed into their petrographic groups: the "Akkar Plain" samples in MBA Group 1 and LBA Group 3; the "Coastal Lebanon" samples in MBA Group 3 and LBA Group 5; the "Northern Coastal Palestine" samples in MBA Group 4 and LBA Groups 1 and 2. For the last grouping, the LBA samples from the "Haifa Bay" (Group 1) and "Northern Coastal Palestine" (Group 2) were kept separate as the petrographic comparison had suggested the MBA samples were similar to samples from both LBA groups. Retaining the separation between the two LBA groups allowed this hypothesis to be tested. Both petrographically and chemically LBA Groups 1 and 2 were distinct.

As previously stated, the ICP and NAA data from the MBA and LBA samples needed to be investigated separately, as combining the MBA ICP and NAA data had not been successful. The ICP data, acquired on two separate occasions[195], from the MBA and LBA

[195] Some concern existed on the comparability of the ICP data as the digestion procedures had been dissimilar and trace elemental data for the MBA data had been acquired by ICP-MS. However, the element Zr was not

data were combined after transformation into base 10 logarithms. Likewise, the NAA data, acquired on a single occasion, were pooled from the MBA and LBA data after being transformed into base 10 logarithms. While the same four statistical tests were employed, only a single run of each test was performed with the problematic elements and any outliers removed. For the MBA data, the petrographic outlier samples (Ownby 7, Ownby 12, Ownby 15, Ownby 25, and Ownby 48), the "General Levant" samples (Ownby 27, Ownby 38, Ownby 46, and Ownby 47), and the Group 2 ("Inland Lebanon") samples were removed. From the LBA data, those samples assigned to Group 4 ("North-west Syria") and Group 6 ("Southern Cyprus") were eliminated[196]. The problematic elements for the MBA ICP data were Cr, Cs, Eu, Lu, Mn, Ni, Sc, V, and Zn, while those for the LBA ICP were Eu, Na, Sm, Yb, and Zr.[197] As the NAA data for both MBA and LBA samples had been acquired at the same time, identical elements were problematic for both data sets, these being Cs, K, Mn, Rb, Ta, and Yb.

### 7.3.4 MBA and LBA ICP data

Although removing fourteen problematic elements from the combined MBA and LBA ICP data seemed drastic, the remaining twelve elements appeared to provide good results. The PCA showed a slight separation of samples by assigned provenance, with those from the "Akkar Plain" (MBA Group 1 and LBA Group 3) separated from the "Coastal Lebanon" samples (MBA Group 3 and LBA Group 5), which showed some separation from the "Northern Coastal Palestine" samples (MBA Group 4 and LBA Groups 1 and 2) (Fig. 7.25). Within the groups, there was a separation of the MBA and LBA samples from the "Akkar Plain", while the coastal samples from both periods tended to exhibit more overlap. This suggested a more significant change between the MBA and the LBA in materials for the Akkar Plain region than for the coastal areas. The three PCs accounted for 77% of the variability with the significant elements being generally similar to those noted for the separate analyses of the data (Table 7.7).

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used as it can be incompletely digested by hydrofluoric acid and the same instrument had acquired the ICP-AES data for both groups (a Perkin Elmer Optima 3300RL ICP-AES). The preliminary statistical examination of the data suggested the combined data were usable and repeat analyses of the same samples were grouped together (see below).

[196] Sample TS# 151 was retained as the element Mn was not used in the analyses and a preliminary PCA did not separate it as an outlier. Its relationship to any of the MBA samples was important to assess.

[197] The highly mobile element P was removed for both the MBA and LBA ICP data.

Fig. 7.25: PCA of MBA and LBA ICP Data, select elements and samples

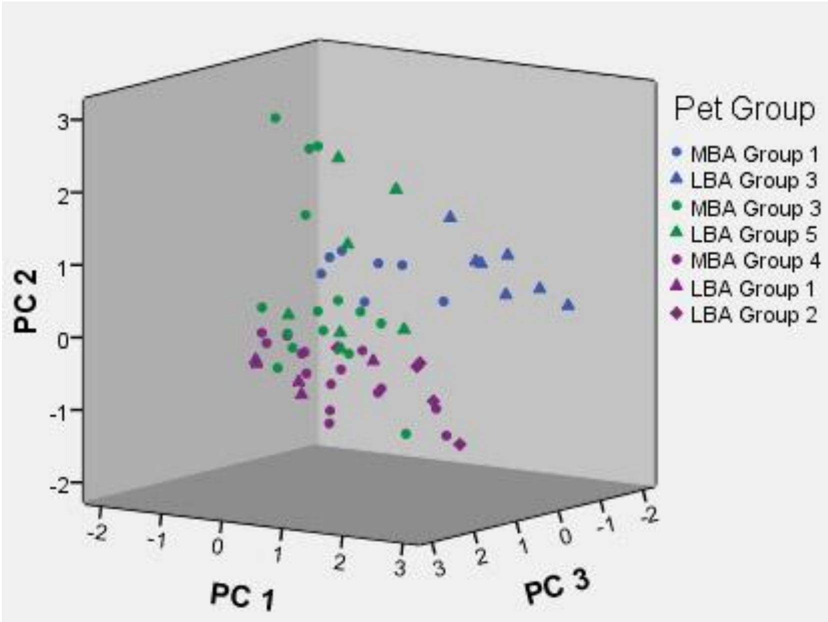


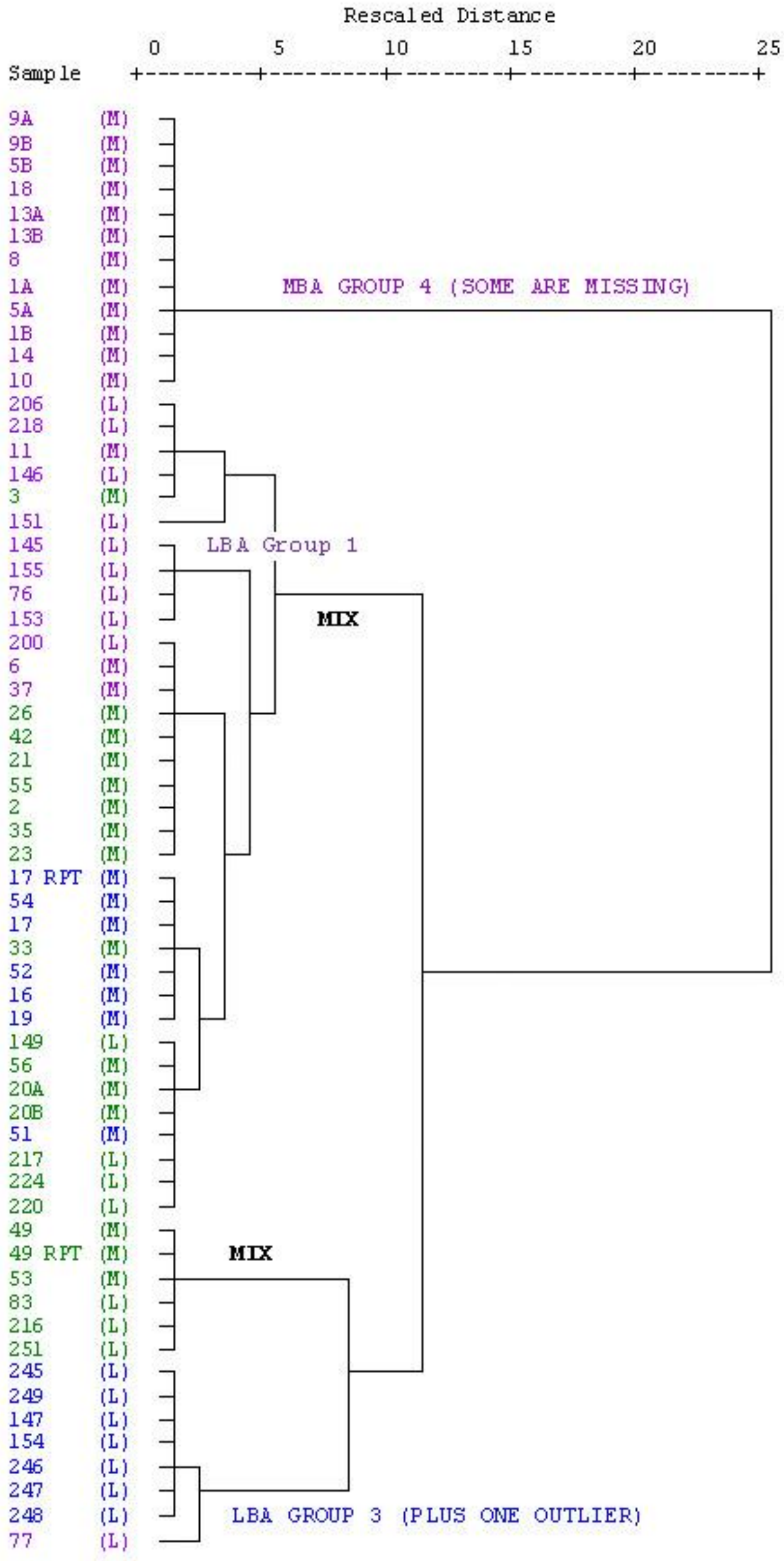

Table 7.7: Elements contributing variability to the first three components, MBA and LBA ICP data, select elements and samples

| PC 1 | PC 2 | PC 3 |
|---|---|---|
| Al, Fe | Ba, Ca, Dy, Mg, Sr | La, Sr, Ti |

The results of the HCA were important for assessing the reliability of the combined data. The placement of the MBA repeat analyses for seven samples in the same cluster, suggested that the data were robust (Fig. 7.26). The LBA "Akkar Plain" samples were placed in their own cluster, although TS# 77 was linked to this cluster[198]. However, the MBA "Akkar Plain" samples were placed in a large cluster with MBA and LBA "Coastal Lebanon" and "Northern Coastal Palestine" samples. The LBA samples from "Haifa Bay", although within this large cluster, were separated indicating they are chemically different from both the MBA and LBA "Northern Coastal Palestine" samples. Surprisingly, the MBA samples from the "Northern Coastal Palestine" were mostly in a single cluster linked at a considerable distance from the other samples. The separation of this group indicates that they are chemically distinct from the LBA samples assigned to this region. The large cluster of MBA and LBA samples assigned to different areas is probably the result of the utilization of rendzina for producing jars in several regions and its continued use from the MBA into the LBA.

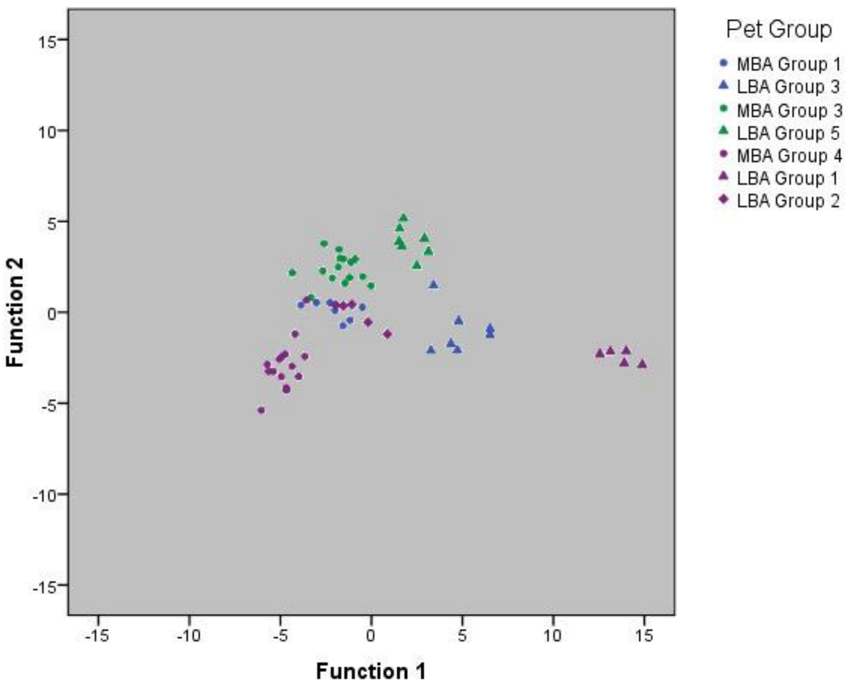
[198] This sample had been identified as aberant in the KCA of the LBA ICP data (see Fig. 7.15), probably due to concentrations of Co and Sm that were different from the other samples

Fig. 7.26: HCA of MBA and LBA ICP Data, select elements and samples (colour of samples related to the petrographic groups as specified for the other statistical tests; M=MBA samples, L=LBA samples)



The DA revealed that the LBA Group 1 samples ("Haifa Bay") are chemically different from any of the other samples, either MBA or LBA (Fig. 7.27). Their production from *Hamra* undoubtedly makes them compositionally distinct, particularly as the other samples were mostly produced from rendzina (MBA Groups 3 and 4, LBA Groups 2 and 5). Once again, the LBA "Akkar Plain" samples (LBA Group 3) were separated from the MBA samples assigned to this area (MBA Group 1). Surprisingly, DA revealed distinctions between the MBA and LBA "Coastal Lebanon" samples (MBA Group 3 and LBA Group 5). This was not obvious from the previous tests, but suggests that some changes in materials acquisition and/or use in this region occurred from the MBA to the LBA. Also unexpected was the placement of the LBA Group 2 samples ("Northern Coastal Palestine") near the MBA Group 1 samples ("Akkar Plain"). This may be the result of the proximity of the LBA Group 5 samples ("Coastal Lebanon"), as the examination of the LBA ICP data had shown the samples from LBA Groups 2 and 5 were compositionally similar ( Figs. 7.9, 7.12, 7.15, and 7.16. MBA Group 4 ("Northern Coastal Palestine") was mostly separated. The overall picture is a division by period, with the MBA samples distinct from the LBA samples.

Fig. 7.27: DA of MBA and LBA ICP Data, select elements and samples



The first KCA was performed with the test specified to create seven groups due to the classification of samples into this number of petrographic groups. The results identified two samples as unique, LBA TS#151 and TS# 77 in Clusters 1 and 2 respectively (Fig. 7.28). These samples had been shown as chemically different in the analyses of the LBA ICP data (Fig. 7.9 and Fig. 7.15). Once again, the LBA "Akkar Plain" samples (LBA Group 3) were separated from the MBA "Akkar Plain" samples (MBA Group 1). Another distinction was made for most of the MBA Group 4 samples ("Northern Coastal Palestine"), which had also been noted in the previous tests. Otherwise, there was general mixing among the "Coastal Lebanon" samples from the MBA and LBA, along with the inclusion of samples from LBA Group 2 ("Northern Coastal Palestine") with MBA samples from all of the areas. A second KCA with only 3 groups designated based on the three provenance areas, revealed a cluster of LBA samples (Cluster 1), a cluster of MBA samples (Cluster 2) dominated by MBA Group 4, and a cluster of mixed MBA and LBA samples (Cluster 3) (Fig. 7.29). Similar to the joint DA, this suggests there are greater differences in composition by period than by region.

Fig. 7.28: KCA of MBA and LBA ICP Data, select elements and samples

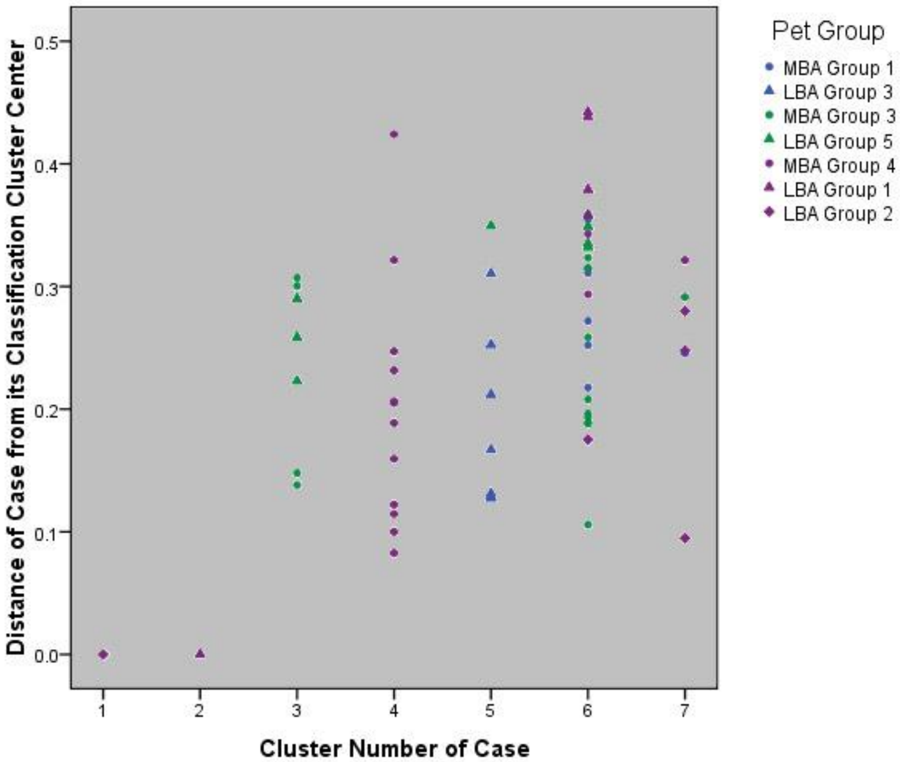
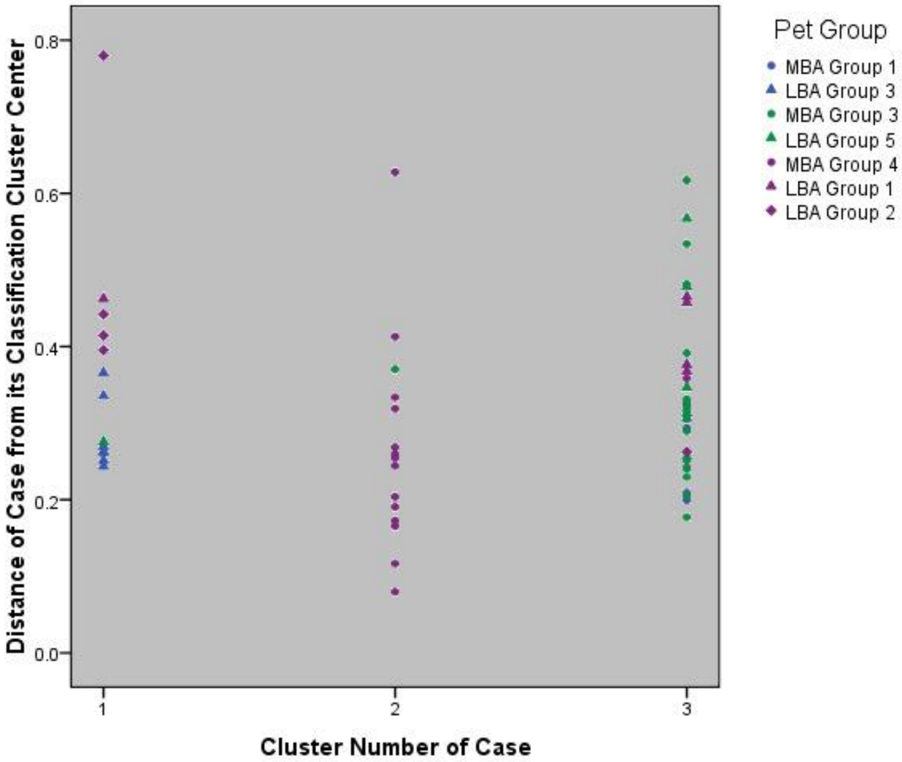


Fig. 7.29: KCA of MBA and LBA ICP Data, select elements and samples




### 7.3.5 MBA and LBA NAA data

The results of the PCA of the MBA and LBA NAA data confirmed the chemical distinctiveness of the LBA "Akkar Plain" (LBA Group 3) samples (Fig. 7.30). The MBA "Akkar Plain" sample (MBA Group 1) was placed with most of the samples from the coastal MBA and LBA groups. There appeared to be little separation by period or location. The first three PCs accounted for 80% of the variability, suggesting that the results provided a good representation of the chemical differences in the samples. Important elements included those that had been significant when the data sets were examined individually (Table 7.8).

Fig. 7.30: PCA of MBA and LBA NAA Data, select elements and samples

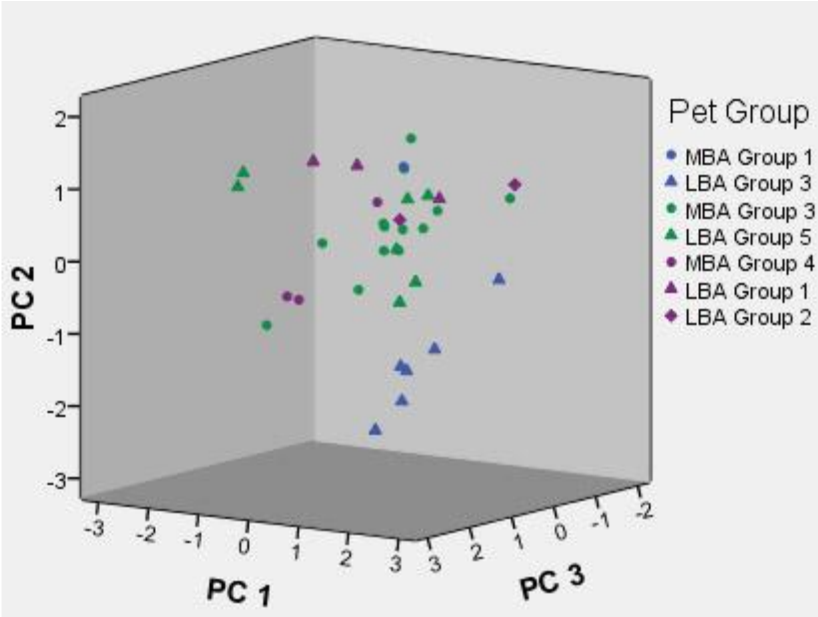
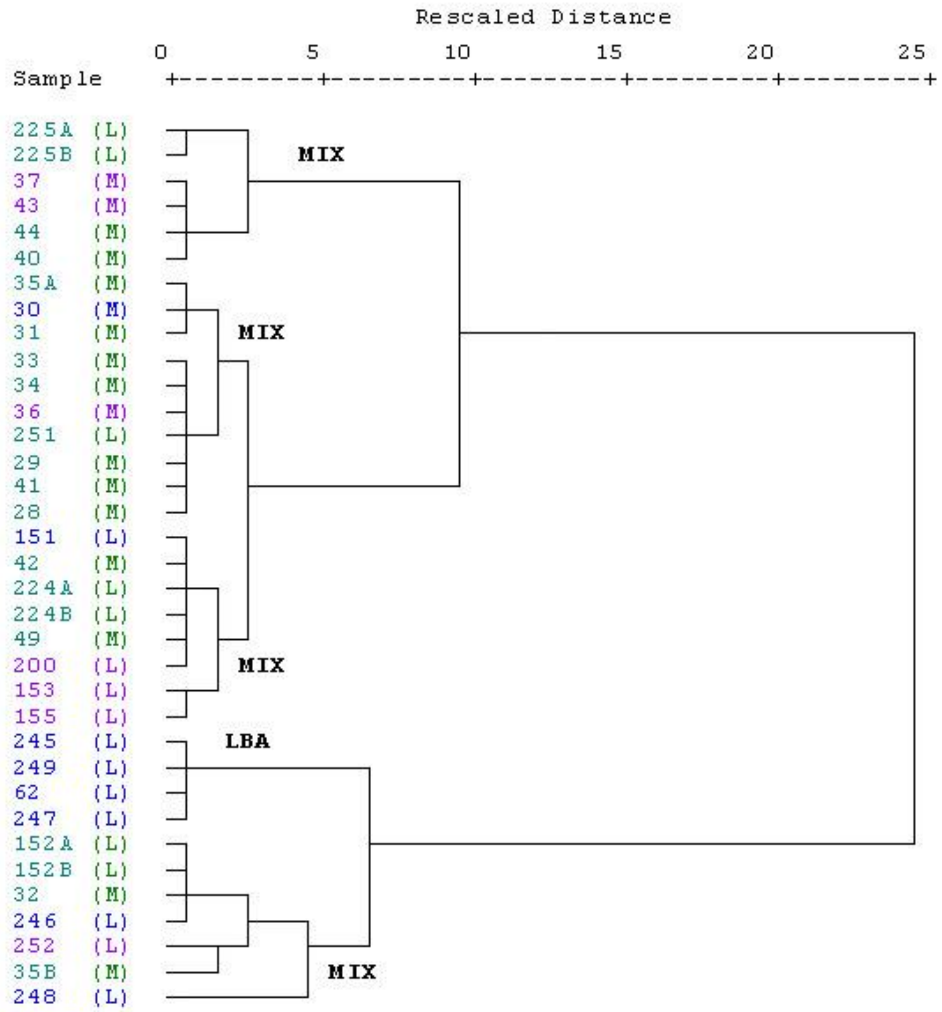



Table 7.8: Elements contributing variability to the first three components, MBA and LBA NAA data, select elements and samples

| PC 1 | PC 2 | PC 3 |
|---|---|---|
| Al, Ce, Eu, Fe, Sc, Sm, Ti, V | Cr, Fe, La, Th | Ca, Na, U |

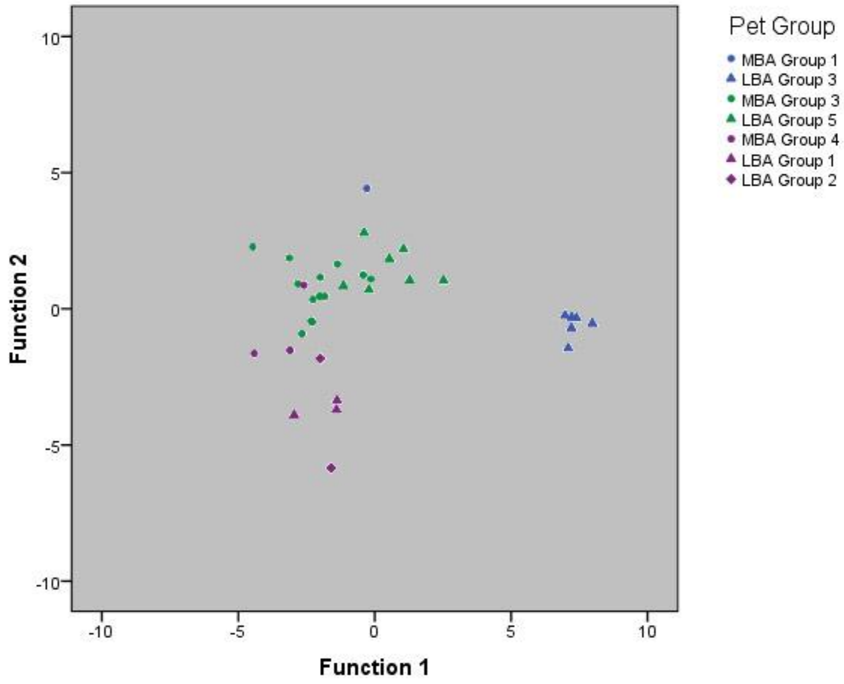
The HCA featured two main clusters, each comprising a mix of samples from the seven petrographic groups (Fig. 7.31). One cluster, however, was dominated by the LBA samples, particularly those from the “Akkar Plain”. The MBA “Akkar Plain” sample was placed in the larger cluster with most of the MBA samples. The mixing of MBA and LBA samples from “Coastal Lebanon” and “Northern Coastal Palestine” had been noted for some of the test results from the ICP joint analyses (Fig. 7.25 and Fig. 7.26). The placement of repeat analyses of samples together in the same cluster indicated that the data were performing well, although the MBA repeat analyses of sample Ownby 35 were separated. This had been seen in the HCA of the MBA NAA data (Fig. 5.45). As the LBA repeat analyses were next to each other this did not raise concern.

Fig. 7.31: HCA of MBA and LBA NAA Data, select elements and samples




The DA clearly separated the LBA Group 3 samples ("Akkar Plain") (Fig. 7.32). However, the MBA "Akkar Plain" (MBA Group 1) sample was also separated confirming its chemical difference from the LBA samples from this region and all other samples. This separation by period was noted for the samples from the "Coastal Lebanon" and "Northern Coastal Palestine". However, the "Coastal Lebanon" samples were less clearly separated, suggesting some chemical similarity. The LBA samples from "Haifa Bay" and "Northern Coastal Palestine" were different from the MBA samples from this region.

Fig. 7.32: DA of MBA and LBA NAA Data, select elements and samples




Finally, KCA was performed with seven groups initially specified. Unexpectedly, the LBA "Akkar Plain" samples were divided into three groups, although none contained the MBA "Akkar Plain" sample (Fig. 7.33). One cluster contained only TS# 248, also noted as different during the KCAs of the LBA NAA data (Fig. 7.23 and Fig. 7.24). Cluster 7 included LBA samples from the "Akkar Plain" and "Coastal Lebanon", but also one MBA "Coastal Lebanon" sample. A mixing of MBA and LBA samples was noted for three other clusters that combined samples from both periods assigned to "Coastal Lebanon", "Northern Coastal Palestine", and "Haifa Bay". One LBA Group 2 sample ("Northern Coastal Palestine"), TS# 252, was in its own cluster, a distinction observed during the KCA of the LBA NAA data (Fig. 7.23). The second KCA was run with three groups designated. Most of the samples were placed into the first cluster, while Cluster 3 only contained sample TS# 248 that was clearly compositionally very different. Cluster 2 contained MBA samples from "Coastal Lebanon" and "Northern Coastal Palestine" along with the repeat analyses of LBA sample TS# 225 from "Coastal Lebanon". This group had also appeared in the first KCA as Cluster 2, suggesting some chemical similarities probably based on the rendzina used to manufacture these samples.

Fig. 7.33: KCA of MBA and LBA NAA Data, select elements and samples

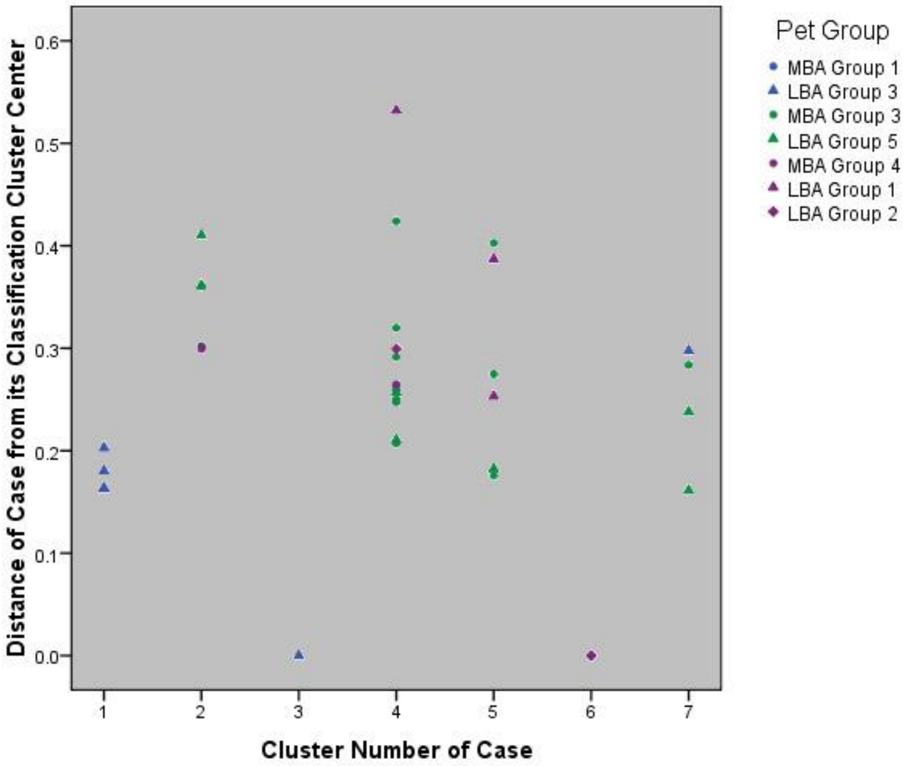
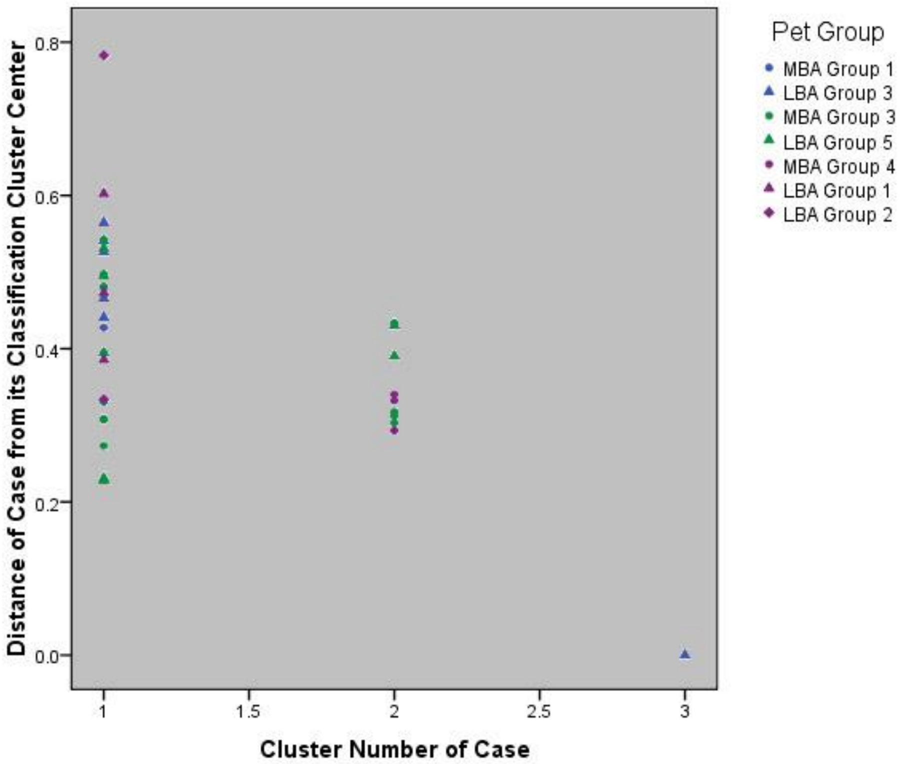



Fig. 7.34: KCA of MBA and LBA NAA Data, select elements and samples



The results from the statistical analyses of the MBA and LBA ICP and NAA data indicate that most compositional differences are due to changes in clay resources used over time rather than changes in localities producing the vessels. For the samples from the "Akkar Plain" (MBA Group 1, LBA Group 3) almost all tests showed chemical differences between the MBA and LBA. Less distinction was present for the "Coastal Lebanon" samples (MBA Group 3, LBA Group 5). Most of the tests separated the MBA "Northern Coastal Palestine" Group 4 and the LBA "Haifa Bay" Group 1 samples suggesting their composition is different both for their individual period and between the two periods. Only with the LBA "Northern Coastal Palestine" Group 2 samples was any chemical similarity noted with the MBA samples deriving both from "Northern Coastal Palestine" and "Coastal Lebanon". This is most likely due to the utilization of rendzina for most of these samples. These conclusions are consistent with the petrographic analyses, which suggested changes in the selection of clay resources between the MBA and LBA for the Akkar Plain area and along the coast of northern Palestine. On the coast of Lebanon, however, similar clay and inclusion materials were apparently employed to produce Canaanite jars during both periods.

## *7.4 Association of LBA Petrographic Groups to Fabric Groups and Vessel Forms*

### 7.4.1 Association of LBA petrographic and fabric groups

The LBA samples analyzed petrographically showed a remarkable concordance between the fabric groups and the petrographic groups (Table 7.9; Bourriau *et al*. 2001; Smith *et al*. 2004)[199]. Therefore, those samples deemed to have derived from the area of Haifa Bay (Group 1) were generally of fabrics P11 and P30, while the samples given the interpreted provenance of the northern coast of Palestine (Group 2) were of fabrics P31, P70, and P71. The Group 3 samples, assigned to the Akkar Plain, were all designated fabric P16. Group 4 samples, interpreted as deriving from north-west Syria, also all belonged to a single fabric group, P40. However, samples within this fabric group were also assigned to Group 6, southern Cyprus, along with samples from fabric group P52[200]. Group 5 samples, probably coming from areas along the coast of Lebanon, were from fabric groups P33 and P51. Overall, there was a good link between the fabric designation and the assignment of the samples to areas of production, unlike the case for the MBA Canaanite jars. This is probably

[199] A summary of the fabric descriptions is given in Table 3.3, page 63.
[200] Initially, the P40 and P52 samples were given a single provenance in Syria (Bourriau *et al*. 2001: 127-132, 142-143), however, further work on the samples separated out those probably deriving from Cyprus (Smith *et al*. 2004: 61-62, 65-70).

the result of a more consistent use of materials in the LBA, evident by the clearer distinction of fabrics. The fact that the petrographic groups contain samples from more than one fabric group indicates that archaeologically defined fabric groups can come from the same area of production. Undoubtedly, this relates to visual differences in the samples, but ones that are consistently identified, creating separate fabric groups.

Table 7.9: Fabric groups within each petrographic group

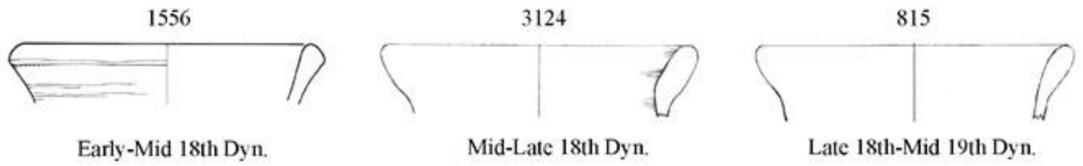
| Petro. Group | Interpreted Provenance | Samples | Fabric Groups |
|---|---|---|---|
| 1 | Haifa Bay | 59, 60, 74, 75, 76, 77, 145, 153, 155 | P11, P30 |
| 2 | N. Coastal Palestine | 79, 80, 82, 146, 151, 200, 206, 218, 252 | P31, P70, P71 |
| 3 | Akkar Plain | 61, 62, 63, 64, 65, 147, 154, 245, 246, 247, 248, 249 | P16 |
| 4 | NW Syria | 90, 98, 99, 100, 150 | P40 |
| 5 | Coastal Lebanon | 83, 84, 85, 149, 146, 152, 216, 217, 220, 224, 225, 251 | P33, P51 |
| 6 | S. Cyprus | 70, 89, 91, 148, 221 | P52/P40?, P40 |

### 7.4.2 Association of LBA petrographic groups and vessel forms

As the link between fabric and petrographic group was clear, the line drawings of rims (provided by J. Bourriau) classified according to fabric can be utilized to examine form differences within the petrographic groups that may relate to different workshops and/or potters. For examination of the jar rims, only those from Levels IV to II were taken, as these were securely dated to the LBA (see Table 3.1, page 55). Each drawing represented a jar rim, while other rims of identical shape were matched to the drawn example. Therefore, each drawing was also a "rim type". The analysis focused on rims assigned through their fabric to the petrographic groups from the "Akkar Plain", "Coastal Lebanon", "Haifa Bay", and "Northern Coastal Palestine" as these areas were also producing jars in the MBA. For the figures, the number at the top of each rim refers to the drawing number. Although a date is given for the type, this does not imply they were restricted to this period, since some occurred in earlier and later levels as well. Further, rim differences may or may not relate to vessels of different body shape (see below), so the discussion is necessarily limited.

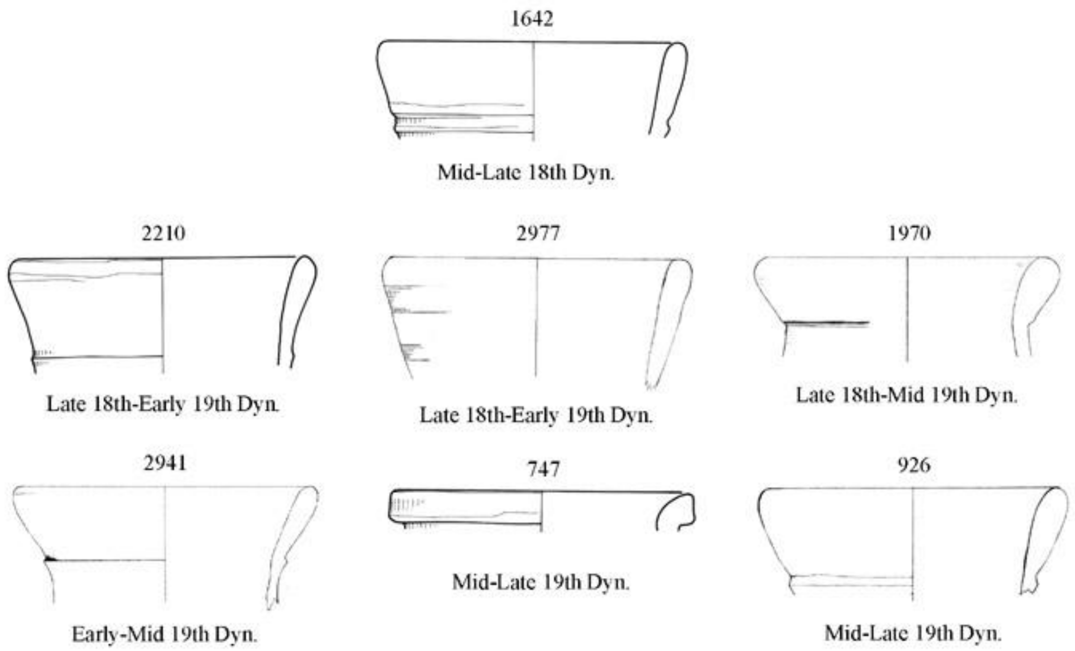
For the "Akkar Plain" fabric P16, three rim types were found in levels dating from the early to mid-18$^{th}$ Dynasty to the late 18$^{th}$ to mid-19$^{th}$ Dynasty (Fig. 7.35). Generally, the rim types are out-curved with one featuring a slight inner gutter (3124), while the two later rim types are more similar than the earlier one that has a curved upper section.  Although the dating of these rims is not very narrow, they do provide an idea of the types probably produced in the Akkar Plain during the LBA.

Fig. 7.35: Line drawings of rim types, fabric P16 assigned to the "Akkar Plain"




For the rim types from fabrics assigned to "Coastal Lebanon" the shape is typically straighter and of a simple type for the early examples (Fig. 7.36).  A change, possibly in the mid-19$^{th}$ Dynasty, produced more bulging and slightly out-curved types.  Type 747 is noticeably different from the other rims and may suggest a workshop or potter producing vessels with very distinct rims.  Further, the three rim types from the same level (IIIA), dated from the late 18$^{th}$ Dynasty to the early 19$^{th}$ Dynasty, are fairly distinct from each other and may also represent the products of different potters and/or workshops, possibly located at separate sites along the coast.

Fig. 7.36: Line drawings of rim types, fabrics P33 and P51 assigned to "Coastal Lebanon"



Rim types from fabrics believed to have been produced in "Haifa Bay" appear similar to those from further north (Fig. 7.37). The form is fairly straight with the latest example more out-curved. The general similarity of the rim types may suggest a single potter/workshop or only a few producing these jars in this more restricted area. The rim types from fabrics assigned to "Northern Coastal Palestine" are distinct and exhibit differences from those of the areas just discussed (Fig. 7.38). The only similarities were found with type 1154 that resembles the rim types from "Haifa Bay" and "Coastal Lebanon". The other types are straight as well, and two (585 and 1172) have a shorter rim area than that seen for the other jar types from the Levant. Once again, the existence of two different types dated to the same period suggests several potters and/or workshops operating simultaneously but producing jars with different rim forms.

Fig. 7.37: Line drawings of rim types, fabrics P11 and P30 assigned to "Haifa Bay" (Group 1)

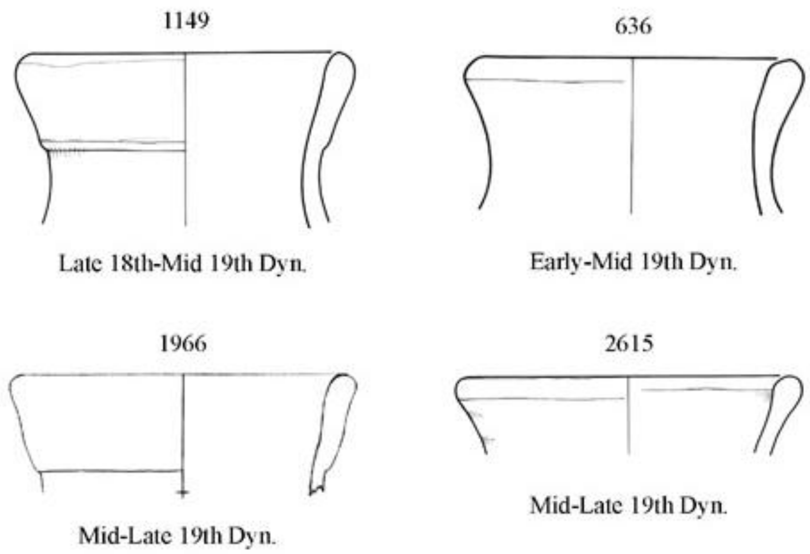
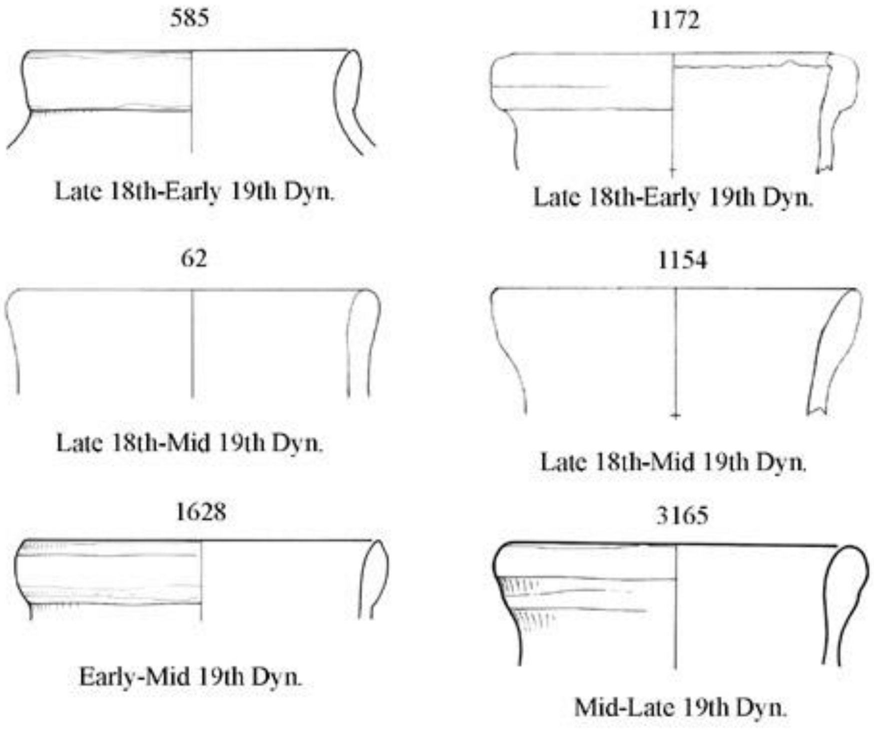


Fig. 7.38: Line drawings of rim types, fabrics P31 and P70 assigned to “Northern Coastal Palestine” (Group 2)

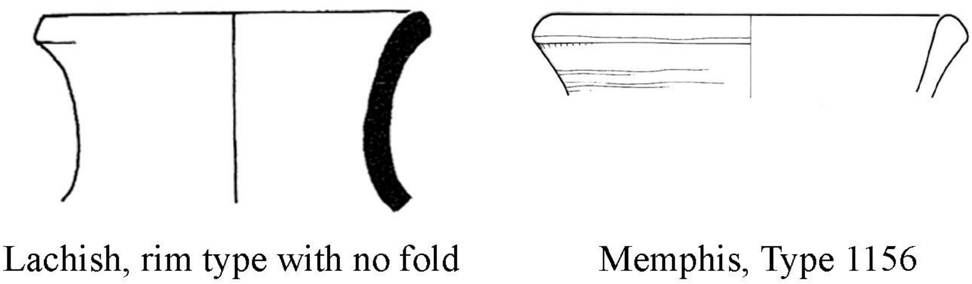



A few rim types were found in more than one fabric from different petrographic groups. For example, rim type 1556 is known for the “Akkar Plain” fabric and a fabric assigned to Haifa Bay (Fig. 7.35). Type 1149 was identified in two fabrics, one believed to have been produced in Haifa Bay and another probably coming from coastal Lebanon (Fig. 7.37). The dominance of simple rims from these areas may have resulted in jars produced in different areas appearing with comparable rim types. These figures illustrate the potential for integrating petrographic information with vessel forms to examine whether different areas produced similar jars and the extent to which jars of various forms were present in a single region. Additional examples from closely dated levels would further clarify regional rim types and their chronological development.

Comparing the LBA Memphis jars with examples from sites in the Levant (here called storage jars) is difficult. Fabric differences are rarely described; as a result, there is little information on whether the jars were locally produced or imported. Since the vessels are usually assumed to function for storage only, little emphasis is given to their role as transport containers or the likely possibility that they were traded within the region[201]. Further, for most coastal sites, if Canaanite jars are published, they are shown as complete vessels with drawings that lack details of the rim profile. For the majority of LBA sites in the Levant, few publications have drawings that show identified Canaanite-type jar rims.

However, a type series of storage jar rims has been developed from the recent excavations at Lachish and comparison can be made to this series, although these vessels could be local or imports. The Memphis type 1556 rim assigned through the fabric to the Akkar Plain and Haifa Bay appears similar to the early LBA storage jar rim type with no fold (Fig. 7.39; Yannai 2004: 1075). In the LB II, several types from Lachish (Clamer 2004: 1193, 1195) appear similar to examples from Memphis, particularly the elongated straight rim and slightly everted rim types (Fig. 7.40). One LBA storage jar rim excavated from Beirut (Badre 1997: Fig. 22) appears similar to Memphis type 1154 believed to derive from the northern coastal Palestine area (Fig. 7.41). Several LB I – LB IIA storage jar rims from Tyre (Bikai 1978: 65, Plate XLIX) resembles those from Memphis (Fig. 7.42). Number 9 is similar to rim type 815 from the "Akkar Plain", while number 10 appears analogous to rim type 1149 from "Haifa Bay". Overall, there is some similarity between the jars at Memphis and those found at sites in the Levant identified as the areas of likely production. The presence of several rim types at a single site in the Levant assigned through the current research to different production locations may support the hypothesis that the jars moved within this region. Caution should be exercised when examining jars from sites in the Levant as they should never be taken as representative of local production unless analyses have confirmed that this is the case.

Fig. 7.39: Comparison of early LBA storage jar rim type from Lachish (Yannai 2004: Fig. 19.8) and Memphis rim type




[201] Recent research by N. Golding (MA student at Tel Aviv University) is clarifying the extent of movement of jars within the Levant during the LBA.

Fig. 7.40: Comparison of LB II storage jar rim types from Lachish (Clamer 2004: Figs. 20.5 and 20.6) and Memphis rim types

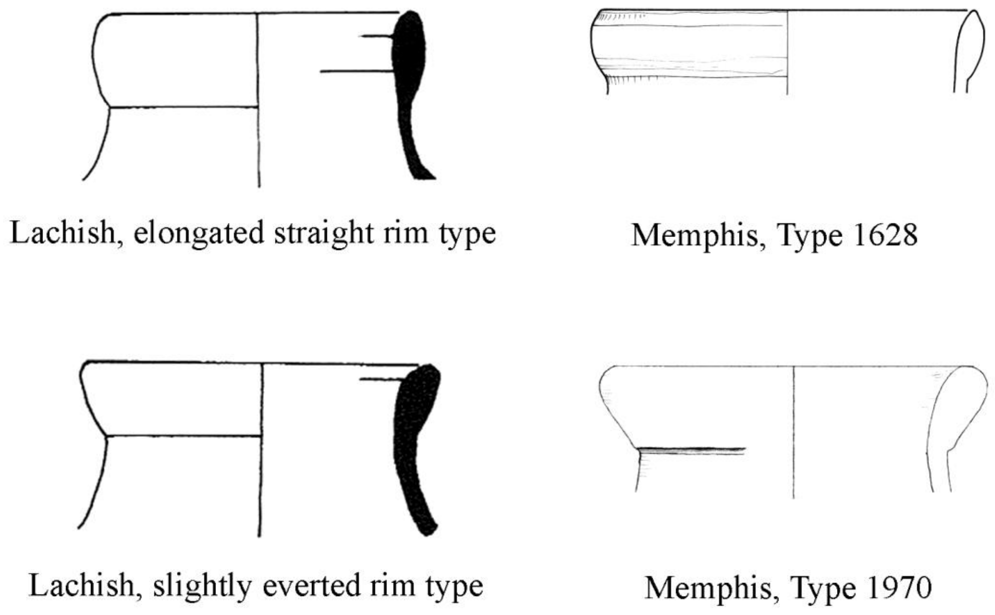



Fig. 7.41: Comparison of LBA storage jar rims from Beirut (Badre 1997: Fig. 22) and Memphis rim types

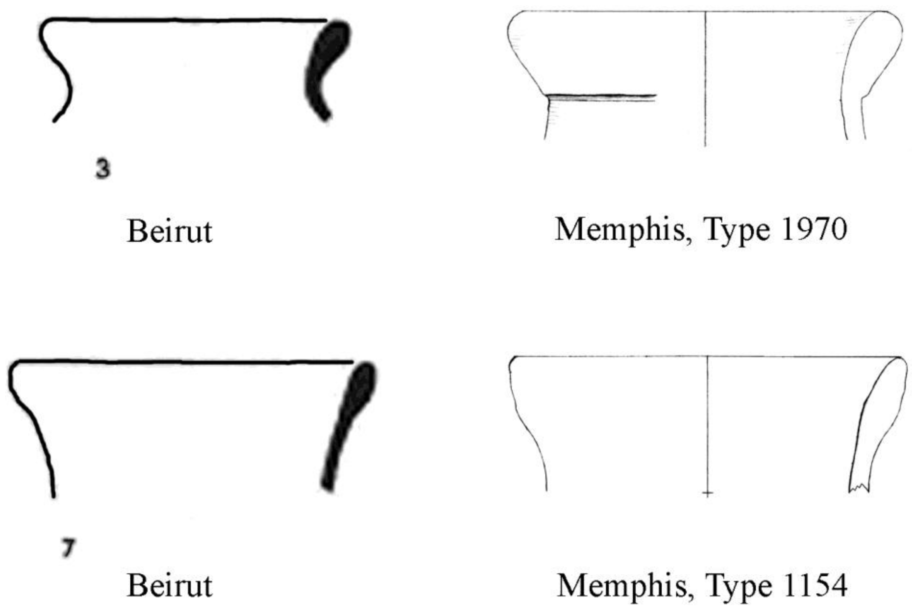
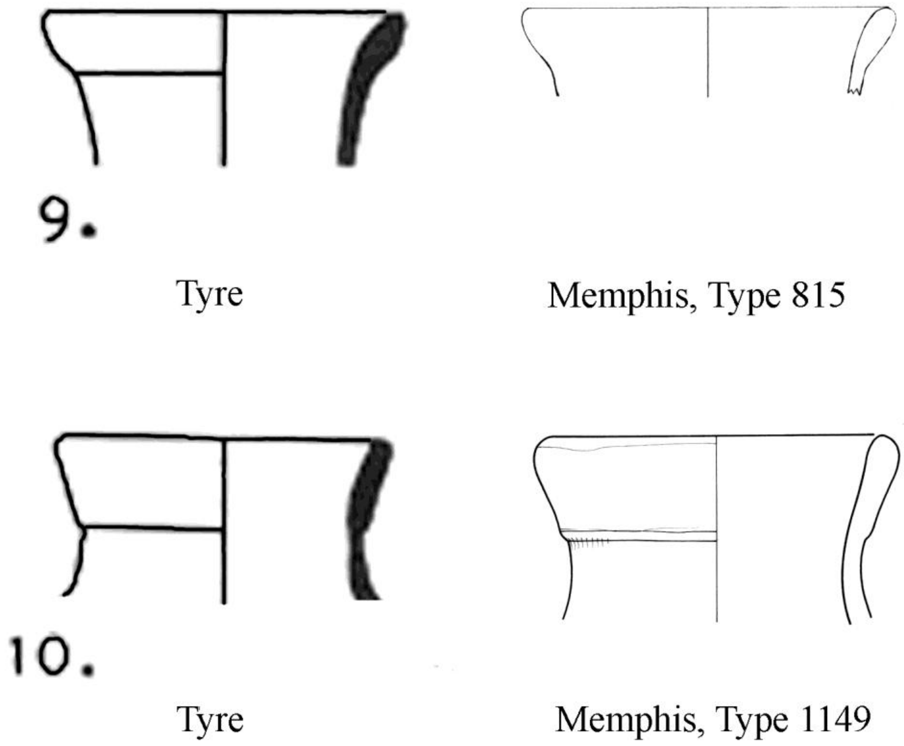


Fig. 7.42: LB I-IIA storage jar rims from Tyre (Bikai 1978: Plate XLIX)




A final method for investigating form differences in the LBA is to examine the jars excavated in Egypt and assigned to one of the fabric groups. For those classified as P11 or P30, probably deriving from Haifa Bay, the chronological differences in form are clear (Fig. 7.43). Further, within the jars dated to the 19th Dynasty, various rims are apparent, while similar rims can be seen on jars with slightly different body shapes. This introduces an additional complication in examining jar form differences by postulated area of provenance when only rims are available for study. Jars of fabrics P31 and P70, assigned to the coast of northern Palestine, also exhibit a variety of body shapes (Fig. 7.44). As the jars from Amarna are closely related in time, their difference further illustrates both the presence of multiple workshops/potters in a region and the variation of body types. However, when these vessels are compared to those of fabric P51, probably manufactured along the coast of Lebanon, the distinct shapes of the latter are clear (Fig. 7.45). While this may support the concept of regionally identifiable vessel forms, the single jar assigned to fabric P40, probably produced in Syria or Cyprus, is very similar in shape to jars of the same date deriving from the Haifa Bay area (Fig. 7.46). Examination of the jars at Amarna also revealed similar shapes in various fabrics, although some features such as shape of shoulders, type of base, and length of rim did seem to relate to some specific fabric types (Serpico *et al*. 2003: 373). Clearly, more research into the connection between rim type, body shape, fabric, and provenance is needed to clarify these issues.

Fig. 7.43: LBA Canaanite jars from Egypt, fabrics P11 and P30 assigned to Haifa Bay (Aston 1996: Plate 10, 1997: Fig. 122, 1998: 643, 1999: Plate 3; Aston & Aston 2001: Fig. 39)

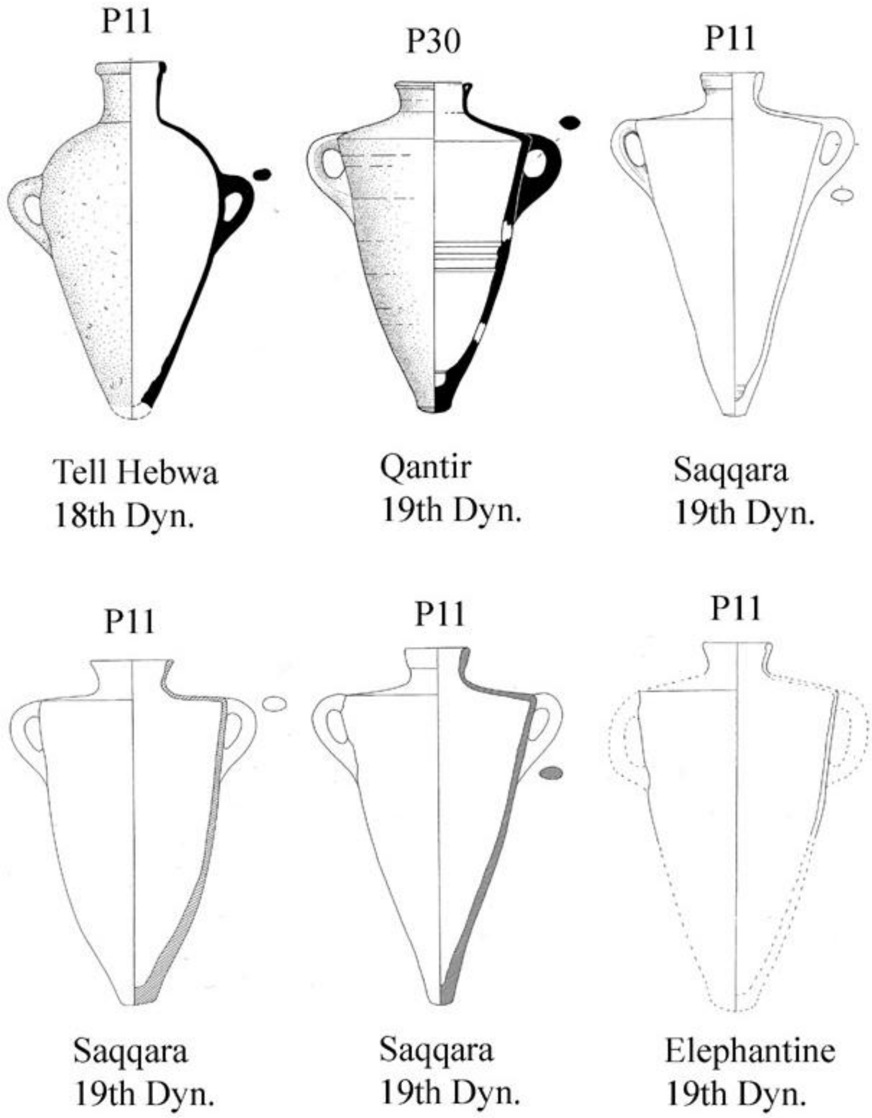


Fig. 7.44: LBA Canaanite jars from Egypt, fabrics P31 and P70 assigned to Northern Coastal Palestine (Aston 1996: Plate 10; Rose 2007: 292-4)

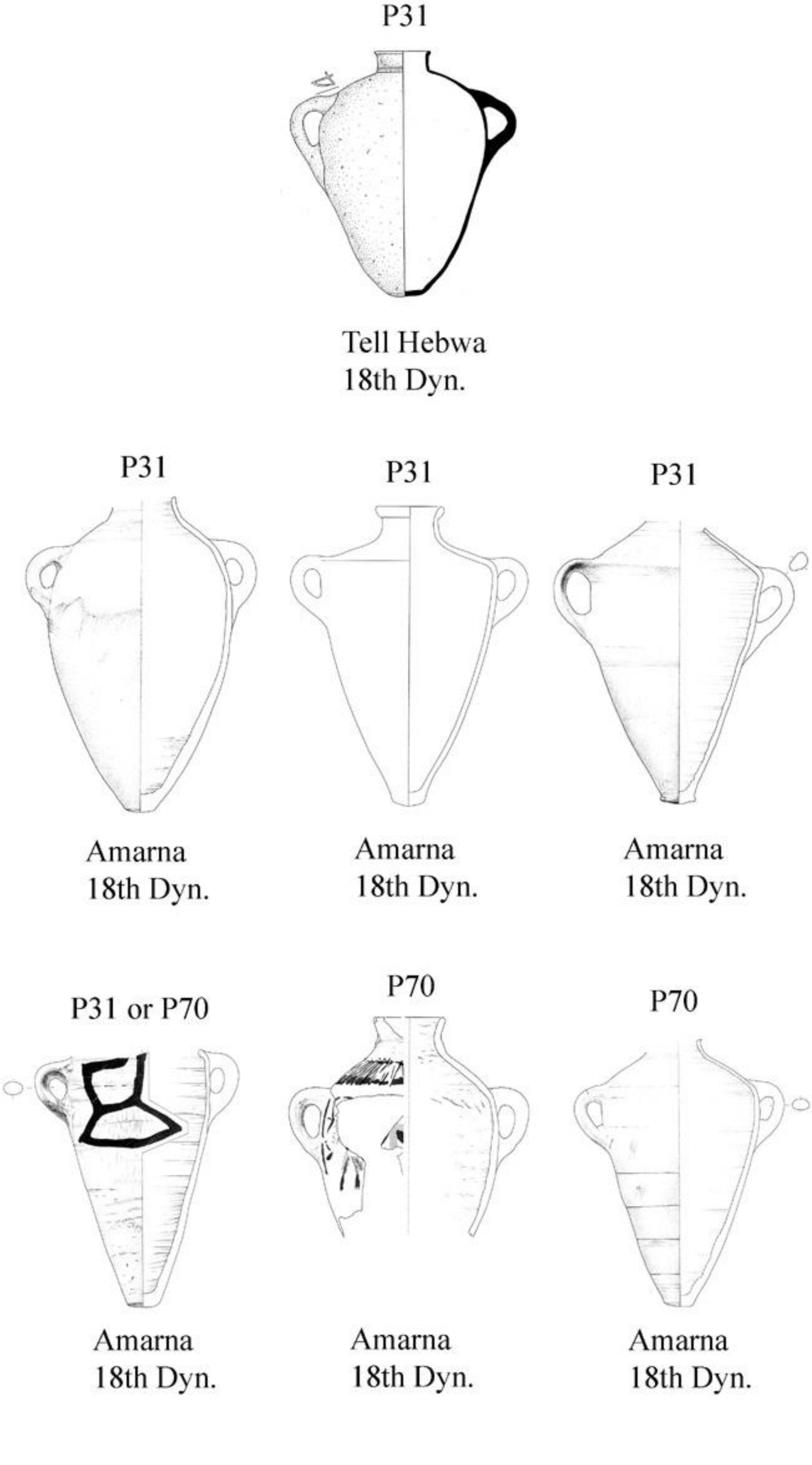


Fig. 7.45: LBA Canaanite jars from Egypt, fabric P51 assigned to Coastal Lebanon (Rose 2007: 292-4)

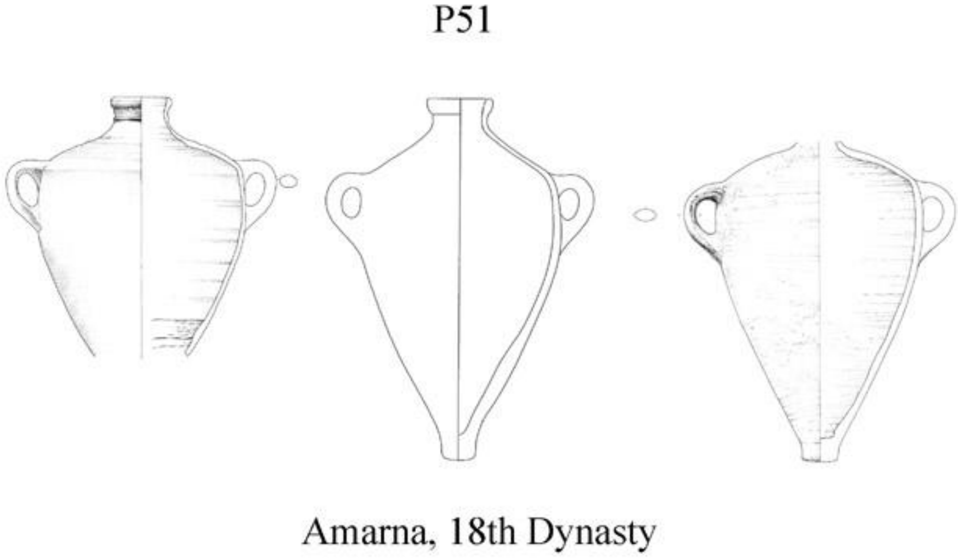
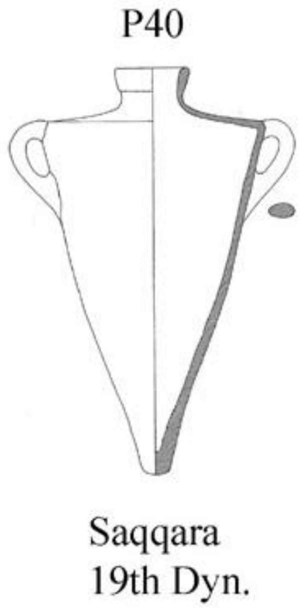



Fig. 7.46: LBA Canaanite jar from Egypt, fabric P40 assigned to North-west Syria or Southern Cyprus (Aston 1997: Fig. 122)




### 7.4.3 Comparison of MBA and LBA vessel forms

The identification of LBA rim types that have been connected through their fabric to potential production areas in the Levant provides an opportunity to assess changes in rim shape over time when compared to the MBA material. However, the difficulty in associating the petrographic groups to the fabric groups for the MBA jar rims resulted in only six that had a suggested provenance based on their macroscopic similarities to sampled sherds (see section 5.5.2). These vessels included two from "Inland Lebanon", one from "Coastal Lebanon", and three from "Northern Coastal Palestine". As none of the LBA jars were identified as coming from an inland Lebanese production area, these rim sherds could be ignored. Comparison of the rim from "Coastal Lebanon" to LBA examples assigned to this region suggested that the rims changed from having an inner gutter to being straighter and simpler. One of the MBA rims assigned to "Northern Coastal Palestine" has a bulging rim dissimilar to the LBA rims believed to come from this area, while the other shows a straighter profile that could easily be the antecedent for LBA rim type 1149. Examination of the MBA rim types that could not be related to a potential provenance area reveals a similar change from more elaborate and bulging types to the straighter and simpler varieties in the LBA. These connections between MBA and LBA rim types deriving from identified areas in the Levant are tentative, particularly as there is a lack of early 18$^{th}$ Dynasty rims. However, they do illustrate the potential for understanding the development of Canaanite jar rim forms in specific regions over time.

## *7.5 Conclusions*

Petrographic and compositional comparison of MBA and LBA Canaanite jars from Memphis revealed both similarities and differences. Petrographically, similarities were noted between some of the MBA jars with those from the LBA assigned to the Akkar Plain, coastal Lebanon, Haifa Bay, and northern coastal Palestine. However, within these groups, samples existed that were not comparable, indicating changes in materials utilized between the two periods. This was clear for the "Haifa Bay" samples that were produced with *Hamra* in the LBA, while this material had not been noted for the MBA samples[202]. Further, the size and amount of basalt inclusions and some of the clays were noticeably different between the MBA and LBA jars believed to have been produced in the Akkar Plain, again suggesting changes in raw materials.

The relationship between the MBA and LBA Canaanite jars was further clarified by the analysis of ICP and NAA data from both groups. Most of the tests confirmed that between the MBA and LBA for the "Akkar Plain" groups different resources and combinations of resources were utilized, possibly due to a change in the site producing

[202] However, *Hamra* was utilized for MBA jars from Tell el-Dab$^{c}$a assigned to the coast of Palestine (Cohen-Weinberger & Goren 2004: 77-78).

vessels. A similar conclusion was reached for samples assigned to northern coastal Palestine, where the MBA group was distinct and the LBA Group 1 ("Haifa Bay") was also unique. Some samples did appear similar between the MBA samples believed to derive from this area and samples in LBA Group 2 ("Northern Coastal Palestine"). Less compositional differences were noted between the MBA and LBA samples probably produced along the coast of Lebanon, indicating more continuity in the utilization of materials and manufacture of jars. Overall, the statistical tests grouped samples more by date than by proposed provenance area. This supports the microscopic data that suggested changes in raw materials and their utilization occurred between the MBA and LBA.

Two regions producing jars in the MBA, "Inland Lebanon" and "Southern Palestine", were not identified in the LBA samples, suggesting that they ceased exportation of materials in Canaanite jars to Memphis. However, the possibility that these two regions exported jars to other sites in Egypt cannot be ruled out, as the quantity of material from Memphis was relatively small. Conversely, jars deriving from "North-west Syria" and "Southern Cyprus" were only noted for the LBA; these areas had apparently not begun to produce Canaanite jars in the MBA. However, some MBA Canaanite jars from Tell el-Dab$^{c}$a were identified as coming from north-west Syria/Cilicia, but their appearance was very different from the Memphis LBA samples (Cohen-Weinberger & Goren 2004: 71-73).

The connection between the LBA petrographic groups and the fabric groups enabled an examination of rim forms that could be assigned to regions of likely production. This revealed general similarities in form between samples probably deriving from the Akkar Plain, coastal Lebanon, and Haifa Bay, although the former tended to exhibit a more pronounced outward curve. The "Northern Coastal Palestine" rim types appeared different and showed a unique development. While chronological changes were illustrated, the presence of varying rim forms for one period suggested several potters, workshops and/or sites producing jars within each of the regions, with the exception of the "Akkar Plain" and "Haifa Bay" examples, although these types were few in number. Comparison to the limited numbers of MBA jar rims assigned to a provenance confirmed the impression that over time, the rims were simplified and became straighter. As significant political changes occurred between the MBA and the LBA, differences and similarities noted for the Canaanite jars may reflect the degree to which political events affected both the manufacture of the jars and the regions exporting them to Egypt.

# Chapter 8: Discussion and Conclusions

## 8.1 Research Summary

### 8.1.1 Aims and methodology

The aim of this thesis was to explore the relationship between trade and politics through a case study derived from the Eastern Mediterranean during the Middle and Late Bronze Age. As both Egypt and the Levant featured complex political systems in these periods, this study of vessels transported from the Levant to Egypt provides a means with which to assess the impact of political situations on trade and vice versa. Within Egypt, the existence of a mixed Levantine-Egyptian population in the eastern Nile Delta created a unique circumstance for trade between Egypt and the Levant. The movement of MBA Canaanite jars in this environment also provided information about intercultural contacts within Egypt. Changes in trade patterns between the MBA and LBA were interpreted in light of political developments in both areas and provided additional information for characterizing MBA trade.

The scientific analysis of transport vessels produced data that could suggest where the jars had been manufactured. While petrography revealed the clay and mineral inclusions indicative of particular geological regions, the compositional data assisted in confirming petrographic groupings and illustrated relationships between these groups. The thin sections also provided a means of comparison of the MBA Canaanite jars from Memphis with those from Tell el-Dab$^{c}$a. This analysis was supplemented by a comparison of images of the MBA sherd chips from the Memphite jars to chips of jars from Tell el-Dab$^{c}$a that were examined macroscopically. Both the thin sections and the compositional data were compared between the Memphite MBA and LBA Canaanite jars. Thus, the methods chosen for the research project were appropriate for providing information on provenance and for comparison to other jar samples.

### 8.1.2 Results

Petrographic and compositional analyses of the MBA Canaanite jars from Memphis revealed four main groupings. Through the recognition of the clay types and inclusions in the thin sections, areas where these constituents existed were identified as possible locations of manufacture. The first petrographic group, Group 1, in all probability represented jars produced in the Akkar Plain due to their conspicuous fragments of black basalt. In this region, the major site of Tell ‘Arqa is a likely location of production. Samples in Group 2 were probably manufactured slightly inland from the Lebanese Coast, due to the lack of coastal components. Byblos was a known trading partner with Egypt, and is the most plausible site for producing these vessels. The coast of Lebanon was identified as the probable provenance for the samples assigned to Group 3 because of the characteristics of the coastal sand inclusions. Several sites in this region, such as Beirut and Sidon, are likely to have manufactured jars. The interpreted provenance of Group 4 was northern coastal Palestine, as the coastal sand temper featured approximately equal amounts of quartz grains and bioclasts. The sites of Akko and Tel Nami are possible production locations. Samples not included in these groups appeared to derive from an area near Ashkelon (Ownby 48), the inland Levant region (Ownby 7 and Ownby 15), and Egypt (Ownby 12 and Ownby 25). Other samples did not contain diagnostic inclusions and were labelled as “General Levant”. Overall, the results confirmed that the dominant exporters of these vessels were sites along the coast of Lebanon. This supports the conclusions reached through the petrographic analysis of imported vessels from Tell el-Dab$^{c}$a (Cohen-Weinberger & Goren 2004), while suggesting that the NAA study of McGovern (2000) may have encountered difficulties in its methodology as noted in several reviews (Bourke 2002; Goren 2003; Aston 2004).

Petrographic analysis also provided information on the technology of production through examination of characteristic changes in the fabric and inclusions indicative of firing temperatures and an assessment of the combination of clay(s) and inclusions. This revealed that most of the jars had been low fired. Unrefined clays were preferred, and materials added to the clay were typically coastal sand and/or *Terra Rossa*. As no correlation could be made between petrographic group and fabric group, no provenance assignment could be made for the drawn jar rims, which had been classified by fabric. However, there were six sherds with rim drawings that, through macroscopic inspection, could be assigned to a petrographic group and so to a provenance. This revealed that rims could be similar in different areas but at the same time vary within a single region. The drawings of the remaining MBA Canaanite jar rims also implied variability in their production. These results suggest that there was inconsistency in the manufacture of these vessels, probably due to the operation of different workshops and possibly because demand for the vessels was not regular.

## *8.2 Political Relationship between Memphis and Tell el-Dab^c^a*

### 8.2.1 Summary of Middle Kingdom and Second Intermediate Period in Egypt

Archaeological and textual evidence from Egypt and the Levant illustrate contacts between these regions in the Middle Kingdom and Second Intermediate Period. Dynasty XII appears to have engaged in trade and probably diplomatic relationships with areas in the Levant, with increased contact in the 13th Dynasty. Examination of ceramics (Aston 2002; Aston 2004a; Cohen-Weinberger & Goren 2004), metal objects (Philip 2006), scarabs (Ben-Tor 1998, 2007a), and cylinder seals (Teissier 1996) found throughout Egypt and the Levant indicates strong contacts with the northern Levant during the unified 12th Dynasty and into the 13th Dynasty. The presence of large city-states actively engaged in intra-regional trade in the Levant and the availability of commodities such as oil, resin, and timber probably encouraged Egyptian trade relations with this area (Van De Mieroop 2007: 103-5; van Koppen 2007: 368-72). By the end of the 13th Dynasty and in the Second Intermediate Period, trade with the northern Levant appears to decrease, possibly as a result of the onset of political disturbances in this region. Contact between Egypt and southern Palestine was always of less significance than that with the northern Levant thoroughout the Middle Kingdom and Second Intermediate Period. The development of large city-states in the MB IIB and MB IIC in the southern Levant does correspond with some increased interaction, particularly with the site of Ashkelon (Dever 1976: 16, 1985: 71-74; Oren 1997: 255-259; Cohen 2002: 109-123; Stager 2002).

Within Egypt, the distribution of Tell el-Yahudiyeh vessels (Bietak 1989a), scarabs (Ben-Tor 1998, 2007a) and metal artefacts (Philip 2006) in the late 13th Dynasty show trade links between the Delta and Nubia via the western desert oases. At the same time, the reduced authority of the Egyptian kings and increased power of the groups in the Eastern Delta appears to have limited interaction between the Delta and Upper Egypt. Further, the Egyptian material culture exhibits regionalism with individual trends for the Delta, Memphis-Fayum area, Middle Egypt, and Upper Egypt (Bourriau in press). This emphasizes the decentralized aspect of the political situation. By the beginning of the Second Intermediate Period, contacts between the Delta and Upper Egypt are almost non-existent and there are fewer examples of goods moving between the Delta and Nubia. This same period saw a stronger Egyptianization of the rulers and inhabitants at Tell el-Dab^c^a (Bietak 1996: 49-54). Examination of the ceramic material culture from Memphis and Tell el-Dab^c^a revealed initial similarities that by the Second Intermediate Period were almost absent (Bader 2009: 680-707). This study found no evidence for the colonization of Memphis by carriers of a MBA culture derived from Tell Dab$^{c}$a. The two areas probably developed along independent cultural lines during the Second Intermediate Period.

### 8.2.2 Interpretation of study results

The comparative analysis of thin sections and chips from the MBA Canaanite jars at Memphis and Tell el-Dab$^{c}$a revealed similarities and differences. The petrographic analysis of the jars from Tell el-Dab$^{c}$a (Cohen-Weinberger & Goren 2004) and the current study showed that some areas produced vessels found at both Memphis and Tell el-Dab$^{c}$a, namely, the Akkar Plain, coastal Lebanon, and northern and southern coastal Palestine. However, comparison between thin sections from these regions revealed noticeable differences in the inclusions and clay. This was due partly to the fact that the Tell el-Dab$^{c}$a thin sections were derived mostly from early 13$^{th}$ Dynasty strata whereas the Kom Rabi'a sequence begins in the mid-13$^{th}$ Dynasty. However, other differences were due to a greater variety of clays seen in the Tell el-Dab$^{c}$a material, while the Memphis samples were mostly produced from rendzina.

The higher variability in the Tell el-Dab$^{c}$a samples was expected. Numerous vessels have been recovered at this site and the excavations were more extensive than those at Memphis. This fact may also account for the presence at Tell el-Dab$^{c}$a of jars identified as products of areas not attested at Memphis. This includes north-west Syria/Cilicia, Mount Carmel, eastern Galilee or Jezreel Valley, the area of the Judea, Samaria, or Galilee hills, and the Shephela/Wadi I$^{c}$ron area (Cohen-Weinberger & Goren 2004). However, jars imported from these areas are rare at Tell el-Dab$^{c}$a, which may further account for why they are not found at Memphis. The examination of the sherd material supported these interpretations and revealed additional areas exporting jars to both sites.

While there are clear similarities in the jars from the two sites, the question of how the MBA Canaanite jars arrived at Memphis is more difficult to address. The jars may have been transported directly to Memphis from Tell el-Dab$^{c}$a. This seems a reasonable scenario, as ancient Avaris lay on the Pelusiac branch of the Nile, facilitating trade north and south, and must have been a major port for the import of goods from the Levant. However, the jars could have come to Memphis indirectly passing through several Delta sites, such as Tell el-Maskhuta. Nevertheless, the similarity of jars found at Tell el-Dab$^{c}$a and Memphis at least indicates that the Egyptians at Memphis were unlikely to have cultivated their own trade networks independently, especially if they were under Hyksos control.

Another consideration is whether the jars would have arrived at Memphis with their Levantine contents intact or have been brought to the site to be re-used. The latter is possible as the Egyptian ceramic repertoire lacks large two-handled storage containers. Further, the relatively low socio-economic standing of the inhabitants of the part of Memphis excavated may suggest the vessels were re-used. However, in all probability Memphis, as the ancient capital, had temples and an active priesthood that may have used Levantine resins in their religious practices, as attested during the New Kingdom. Thus, the jars may have come to the site for use in the temple and then been passed to the artisans when they were empty. This may account for their presence at Memphis at a time when MBA Canaanite jars were generally rare in Egypt south of Memphis (see section 3.3.4)[203]. The proximity of Memphis to the eastern Delta must also be considered. At both Memphis and Tell el-Dab$^{c}$a, the most common jars were imported from the coast of Lebanon. Likewise at the two sites, the less commonly imported jars originated from the Akkar Plain and northern and southern coastal Palestine. The similarity in frequencies of jars at Tell el-Dab$^{c}$a and Memphis from specific areas could argue in favour of either vessel re-use or local demand for Levantine products.

However, the presence at Tell el-Dab$^{c}$a of jars produced in areas not attested at Memphis, particularly the Judea, Samaria, or Galilee hills region, may also be due to the unique demands of the Levantine population in the Delta. Tell el-Dab$^{c}$a did not only receive transport vessels suggestive of commerce from the Levant (Cohen-Weinberger & Goren 2004: 92-98). Bowls, platters, and cooking pots produced in the Akkar Plain (or Middle Orontes or Yarmuq area or Eastern Galilee), near Byblos, along the coast of Lebanon, in the Mount Carmel region, along coastal Palestine, and the areas of the Judea, Samaria, or Galilee hills, and the Shephela/Wadi I$^{c}$ron were also found at the site. This suggests that these items were either brought to Tell el-Dab$^{c}$a by settlers from the region, or imported as desired goods or for use in food preparation and consumption by peoples indigenous to those areas. Thus, if some jars were also being used to import foodstuffs from areas where the Tell el-Dab$^{c}$a inhabitants had originated, then there may have been no demand for such commodities by Egyptians at Memphis. This may suggest that only jars containing products of interest to the Egyptians were imported to Memphis.

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[203] An exception is the site of Lisht, the capital of Egypt during the 12th and 13th Dynasties. Jars at this site are dated to the 13th Dynasty and possibly represent royal acquisition of Levantine goods.

These differences, and the similarities noted above, indicate a less than straight-forward relationship between the Delta populations and the Egyptians at Memphis. If Memphis was under political control by the Hyksos, it was not manifested in similarities in material culture (Bader 2009). While some contact is suggested by the presence of Canaanite jars in Memphis similar to those at Tell el-Dab$^c$a, their paucity at Memphis indicates trade relations between the two sites were not extensive. Finally, in terms of understanding trade between Egypt and the Levant in the late MBA, the presence of Levantine peoples in the Nile Delta clearly played an important role and undoubtedly affected the choice of region from which the jars were imported. The demand by the local population appears to have been more important than any desire for Levantine products throughout the Nile Valley, and the Hyksos could have been actively controlling contact between Egypt and the Levant. Further, large numbers of jars are rarely found outside of the Delta region and they could have reached these sites indirectly and/or as vessels for re-use. The numerous jars at the large site of Tell el-Dab$^c$a also argues for this. However, imported commodities could have been placed in Egyptian containers for distribution south of the Delta. An example may be the Marl C storage jar inscribed “wine from Syria” in the burial of King Hor dated to the 13$^{th}$ Dynasty (De Morgan 1895: 74, Figs. 164-5). Thus, despite or because of the political situation with the northern half of Egypt putatively under Hyksos control, contact on a small scale probably did exist between the mixed Levantine-Egyptian population in the Delta and the nearby Egyptian population at Memphis.

## *8.3 Changes in Trade from the Middle to Late Bronze Age*

### 8.3.1 Summary of New Kingdom in Egypt and MBA and LBA in the Levant

During the Middle Bronze Age in the Levant, many large city-states were present in Syria and northern Lebanon (Van De Mieroop 2007: 103-5). These states acted as intermediaries in trade between the Eastern Mediterranean and the inland empires of Babylon and Assyria (van Koppen 2007: 368-72). However, starting with the sack of Mari by the King of Babylon and the attack on Alalakh and Aleppo by the Hittites, this area witnessed a decline; eventually, the powerful empire of Mitanni arose in the Upper Euphrates. The southern part of the Levant saw the reestablishment of cities in the MBA (Cohen 2002: 107-128). By the MB IIB, many city-states were fortified (Gophna & Portugali 1988: 17-20). The subsequent decline of these city-states was possibly due to the actions of several Egyptian kings of the early 18$^{th}$ Dynasty (Weinstein 1981).

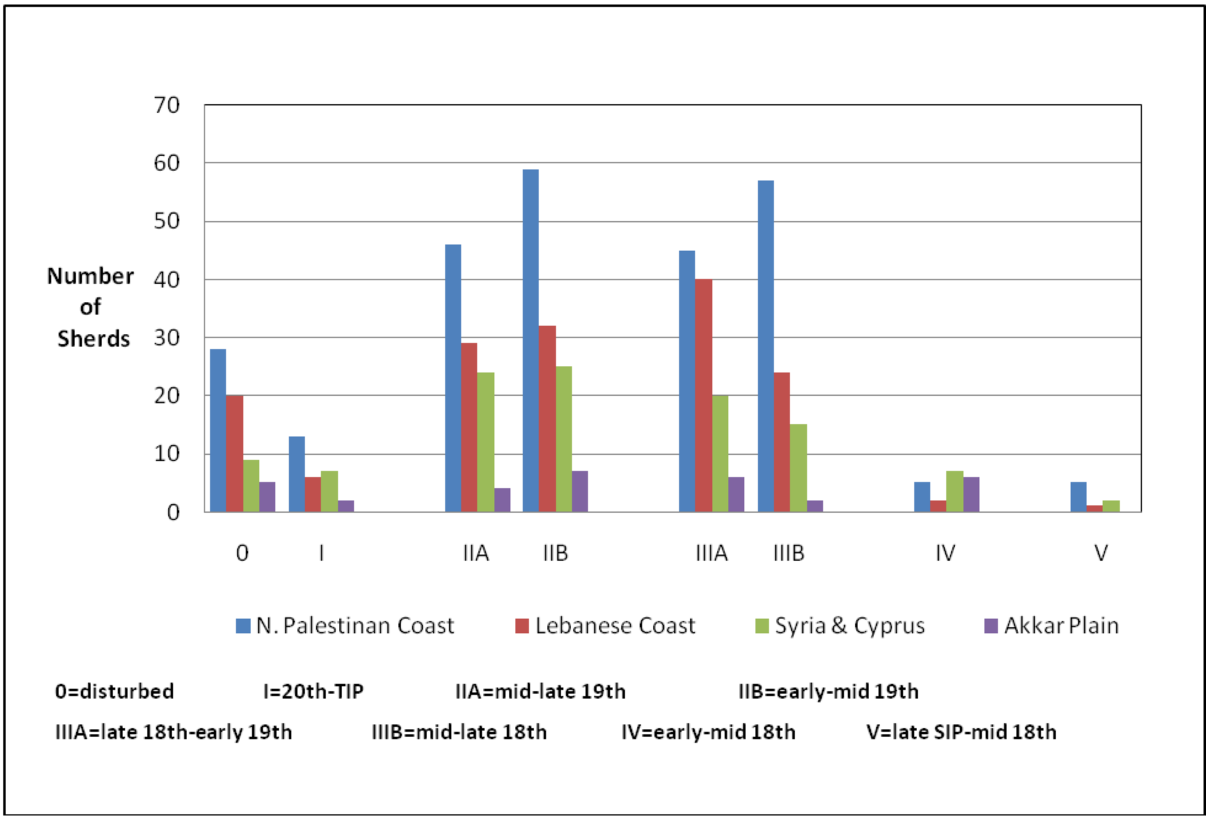
At the beginning of the 18th Dynasty, Egypt was reunited under the Theban King Ahmose (Bourriau 2000: 211-212). Shortly after the fall of the Hyksos dynasty, Egypt began to acquire territory in the Levant and to engage in diplomatic relationships with the inland empires. This resulted in trade between Egyptian-controlled areas of the Levant and Egypt, and perhaps was one of the reasons Egypt sought to acquire this region. In the early part of the 18th Dynasty, military campaigns were necessary to maintain this territory, while the late 18th Dynasty saw a more diplomatic character to contact between Egypt and the Levant (Bryan 2000; van Dijk 2000). However, with Seti I and Ramesses II of Dynasty XIX, war resumed in the Levant and areas such as the Akkar Plain region, which was termed Amurru, were heavily contested between the Egyptians and the Hittites. Ultimately, the region came under Hittite control and peace was attained between this empire and Egypt. This situation did not last long as the movement of the so-called "Sea Peoples" caused the collapse of the Hittite Empire and destabilized the whole region, with Egypt eventually losing is Levantine territory. The affect of these events on trade is of primary interest.

### 8.3.2 Interpretation of study results

Comparison of the petrographic and compositional data from the MBA and LBA Canaanite jars found at Memphis provided information on how the change in political situation may have affected trade. The coastal area of Lebanon seems to have remained the most stable between the two periods. This region exported jars to Egypt in both the MBA and LBA, and the comparisons suggested a similarity in materials through time. The primary difference appeared to be the greater refinement of materials in the LBA that may have been due to more consistent production, probably as a result of increased demand as attested by the numerous LBA Canaanite jars in Egypt (see section 3.3.4). This area seems to have suffered little in the wars carried out by the Egyptian kings in the Levant. Disruption of the export of valuable commodities from this region to Egypt was apparently avoided. In fact, control of the economically beneficial trade from sites along the Lebanese coast may have been a motivating factor in Egypt's development of an empire in this region. However, the area's dominance as an exporter of jars to Egypt in the MBA, attested at Memphis and Tell el-Dab^c^a, was not realized in the LBA. An analysis of the LBA jars sherds at Memphis by their fabric assignment, which in this case can be linked to potential provenances, revealed that northern coastal Palestine had become the main exporter of Canaanite jars in the LBA (Fig.

8.1). The chart also illustrates that the stability of the Egyptian ‘empire’ in the mid to late-18th Dynasty coincided with a dramatic increase in Canaanite jar sherds at Memphis.

Fig. 8.1: Frequency of LBA Canaanite jar sherds by level and potential provenance, as identified through the relationship of fabric and petrographic group




The northern Palestinian coast also continued to export commodities in jars to Egypt from the MBA to the LBA. However, the petrographic and compositional data revealed changes in production of the jars took place between the two periods. Some of the LBA vessels, probably deriving from Haifa Bay (LBA Group 1), were produced of *Hamra* clay, while most of the MBA jars suggested to be from this area were made from rendzina. The abandonment and destruction of cities in this region at the end of the MBA may have disrupted production. When manufacture was resumed, the site and/or production methods had changed. The city of Tell Abu Hawam, suggested as the most likely production location in the LBA, appears to have only been active in this period and was an Egyptian trading centre (Balensi *et al*. 1993; Artzy 2007). Along with being a port, the city may have produced Canaanite jars for export resulting in a more consistent production of vessels utilizing a particular recipe, which included materials that had been employed less frequently in the MBA[204]. LBA jars manufactured along the northern coast of Palestine (LBA Group 2) did have some similarities to the MBA jars probably deriving from this region, but the similarity was mostly in clay and less so in the inclusions. Thus, between the MBA and LBA in this region, both the sites of production and the manufacturing process probably changed. This area did not see much military activity, and the ports in the region were undoubtedly of interest to the Egyptians for the export of commodities to Egypt. However, the Egyptian interest, unlike that of the population at Tell el-Dab$^{c}$a, appears to have been more focused on coastal Palestine than the Lebanese coast. This probably reflects Egypt's greater control of this region, as seen in the Amarna Letters and numerous administrative centers, while the people at Tell el-Dab$^{c}$a had closer ties with sites along the coast of Lebanon.

An analogous situation appears to have taken place in the Akkar Plain. Both petrographically and chemically, the MBA and LBA jars assigned to this region are noticeably different. The MBA jars were made of one clay type and featured infrequent, large basalt inclusions. The LBA jars were made of two different clays, with small, frequent basalt grains found in both. These differences, particularly the utilization of a different clay, may suggest that the production location moved between the two periods. Tell 'Arqa was large and prosperous in the MBA, as it controlled access to the Mediterranean coast by the empires on the Euphrates via the city-states of Qadesh, Qatna, and Mari (Thalmann 2006). However, the city appears to have declined in the LBA, while Tell Kazel became the dominant city in the region, probably due to its status as an Egyptian administrative centre (Badre *et al*. 1994: 310-346; Badre & Gubel 1999-2000: 136-179, 197-200). Based on this and the similarities of some of the LBA jars to Amarna tablets from Tell Kazel and locally produced pottery, it seems likely that during the LBA this site became a main producer of Canaanite jars (Goren *et al*. 2003: 7-8; Goren *et al*. 2004: 109-111; Badre *et al*. 2005: 20-23). This may suggest Egyptian influence or possibly control over the export of commodities to Egypt. Interestingly, this region was one of the most problematic for the Egyptian empire. During the mid-18$^{th}$ Dynasty the area became its own kingdom, called Amurru, although owing allegiance to Egypt. During the 19$^{th}$ Dynasty, the area was contested between the Egyptians and the Hittites with several key battles fought nearby at Qadesh. These disturbances may explain why Canaanite jars from this region are consistently the rarest at Memphis from the mid-18$^{th}$ Dynasty until the end of the New Kingdom (Fig. 8.1).

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204 While *Hamra* was rarely used for the Memphite vessels, it was utilized to produce some MBA jars from Tell el-Dab$^{c}$a assigned petrographically to the coast of Palestine (Cohen-Weinberger & Goren 2004: 77-78).

Further changes in trade with the Levant are the lack of the LBA jars deriving from areas in inland Lebanon or southern Palestine. During the MBA, a fair number of jars appear to have been produced at a site that utilized unrefined rendzina close to the parent rock as raw materials, possibly Byblos (Jidejian 1971). If the identification is correct, absence of such jars in the LBA is remarkable as Byblos had been a trade partner of Egypt since the Early Bronze Age. However, the Amarna letters (Moran 1992) provide ample evidence that this site was under constant threat from its neighbours, particularly those to the north in Amurru. Furthermore, Byblos was not selected as an Egyptian administrative centre, and archaeologically only a few scarabs of the 18th Dynasty and inscribed objects of Ramesses II of Dynasty XIX suggest contacts with Egypt (Jidejian 1971). While the Amarna letters attest to Egypt's continued relationship with Byblos and the acquisition of wood, the military disturbances may have resulted in cessation of export of jars from the site or from nearby locations (Moran 1992). However, difficulties attaining the commodity carried in these vessels may also have affected export of jars. This may explain the drop in numbers of jars exported to Tell el-Dab^c^a from this area (Group D) in the late 13th Dynasty (Cohen-Weinberger & Goren 2004: 83). This decline continued in the Second Intermediate Period, and the area may never have resumed export of commodities to Egypt. Nevertheless, the current study suggests the location producing the MBA jars assigned to "inland Lebanon" was apparently no longer active in the LBA.

While only one sampled MBA Canaanite jar from Memphis was probably manufactured in southern coastal Palestine[205], a fair number postulated as being from this area were found at Tell el-Dab^c^a (Cohen-Weinberger & Goren 2004: 71). Surprisingly, none of the LBA jars were identified as deriving from this area or any region in inland Palestine. This dramatic change in importation of commodities is surprising as this region was a part of the Egyptian empire and administrative centres were established at the sites of Beth Shean, Joppa (Jaffa), and Gaza (Na'aman 1981: 177). In fact, ceramic evidence from Deir el-Balah, Beth Shean, Tel Seraʿ, and Ashkelon suggest that Egyptians were living in the region as a part of the bureaucratic system of Egypt's empire (Martin 2004, 2007, 2008; Mullins 2006). Therefore, both by land and sea the Egyptians had easy access to products from this region that could have been exported in locally made Canaanite jars, as was done in the MBA. One important difference between the two periods was the removal of the Hyksos dynasty at Tell

[205] Additional jars produced along the coast of southern Palestine may have been at Memphis, but the difficulties in linking the examined samples to the unsampled sherds through their fabric appearance meant this could not be determined.

el-Dab[c]a. The mixed Egyptian-Levantine population at the site appears to have remained, gradually becoming more "Egyptianized" (Bietak 1996: 67, 2007: 432, Bietak in press) However, during the late Middle Kingdom and Second Intermediate period, exports from southern Palestine were always much less than those from the northern Levant (Cohen-Weinberger & Goren 2004: 80-84). With the establishment of the Egyptian Empire in the Levant the demand for southern and inland Palestinian commodities carried in Canaanite jars seems to have ended. As discussed in Chapter 3, textual and residue data suggests that goods imported from the northern Levant were mostly resin, oil, and possible wine. This region had the proper climate for growing trees that could produce resin and oil. However, southern Palestine would not have been able to export such commodities, although there is currently no evidence for what products were coming from this region. In any case, what few goods were imported from the region by the inhabitants at Tell el-Dab[c]a were apparently not of interest to the Egyptians. Thus, without a strongly Levantine population in the eastern Nile Delta, the importation of jars from this region ceased[206].

Conversely, while some areas were no longer a part of the trade network with Egypt in the LBA, new areas became participants. This applies principally to north-western Syria and southern coastal Cyprus. During the MBA a handful of jars from northern Syria or Cilicia were imported to Tell el-Dab[c]a during the 15th Dynasty (Cohen-Weinberger & Goren 2004: 71-73, 82). However, the petrographic appearance of these vessels (seen while examining the Tell el-Dab[c]a thin sections in Vienna) is quite different from the LBA Canaanite jars assigned a provenance in north-west Syria. Although both groups contain inclusions indicative of the ophiolite complex in this region (see Chapters 6 and 7), the clay employed for the MBA jars was dark red and rich in serpentine and mica, while the clay utilized for the LBA jars was a calcareous marl. Therefore, the production of jars in this region may have begun at the end of the MBA, but either the particularly workshop producing the vessels ceased to operate, or a change in materials occurred in the LBA. During the latter period, based on the similarities of the LBA Canaanite jars to lamps from Ugarit, it seems likely that Ras Shamra began to manufacture Canaanite jars for export to Egypt. Ugarit was prominent in MBA trade, but became an even larger trade emporium in the LBA, as illustrated by the storeroom filled with LBA Canaanite jars discovered at Ugarit's port, Minet el-Beida (Fig. 3.27, page 76; Schaeffer 1932: 3-4, Plate III.3, Yon 2006). The increased importance of Ugarit was based on its location on the coast of the

[206] Petrographic work is needed on the LBA material from Tell el-Dab[c]a to ascertain if vessels from southern Palestine reached this site.

Mediterranean where it could bring together copper from Cyprus and tin from regions in the Near East as a package for producing bronze. Along with LBA Canaanite jars, these commodities were traded throughout the Eastern Mediterranean, as revealed by the Uluburun shipwreck (Bass 1986; Pulak 1997). The lucrative trade carried out by the city was undoubtedly of interest to both Egyptians and Hittites. Ugarit was a part of the Hittite Empire for most of the LB II period, although it was briefly under Egyptian control. Political and/or military events do not seem to have affected the site's involvement in Eastern Mediterranean trade. Therefore, both trade and politics may have had a role in the development of the region of north-west Syria as a manufacturer of Canaanite jars.

The emphasis on bronze production in the LBA clearly had an impact not just on Ugarit, but also on Cyprus as the main supplier of copper in this period (Muhly 1986). Although the area does not appear to have produced Canaanite jars in the MBA, towards the end of this period, Cyprus began exporting fine-ware ceramics to the Levant and Egypt (Maguire 1990). Consisting mostly of White Slipped and Lustrous Wheel-Made wares, these exports brought Cyprus into the Eastern Mediterranean trading networks (Eriksson 1993, 2007; Karageorghis 2001; Hein 2007). By the LBA, both copper and ceramics were exported, and products in LBA Canaanite jars were imported as attested most clearly at Hala Sultan Tekke and Maa-*Paleokastro* (Hadjicosti 1988; Åström 1991a). Excavations at the former site also produced Egyptian pottery, particularly amphorae, suggesting either direct or indirect (via the Levant) trade in goods from Egypt (Eriksson 1995). Thus, the greater interaction of Cyprus in Eastern Mediterranean trade probably resulted in the production of Cypriot Canaanite-type jars that were exported to Egypt. Cyprus was probably an independent state to judge by the Amarna Letters and appears to have remained so throughout the LBA (Moran 1992). The production of Canaanite jars on Cyprus, while influenced by its role in trade was only indirectly affected by Egypt's Levantine Empire that fostered more intercultural contacts. The political situation of the time that was focused on trade seems to have encouraged the manufacture of Canaanite jars in southern Cyprus.

The petrographic analysis of the MBA and LBA Canaanite jars also revealed evidence for their production. Similarities in both periods include the use of a low firing temperature and the selection of generally calcareous clays. The inclusions are typically coarse-sized and poorly sorted, consisting either of material natural to the clay or tempering materials such as beach or riverine sand. However, in areas that produced vessels during both periods, differences in the manufacture of transport jars are evident. While rendzina clays are still utilized in the LBA along the coast of Lebanon and to a lesser extent the northern coast of

Palestine, a more consistent use of *Hamra* clay was noted for the latter region. In the MBA, the clay appears to contain many large natural inclusions and the only temper employed was coastal sand, particularly along the northern coast of Palestine. During the LBA, the rendzina clays that were utilized lacked large clay-derived grains, suggesting either intentional refinement by the potter or the selection of clays that had undergone natural levigation. The use of refined clays may have necessitated the addition of temper, consisting of beach and riverine sand, as is apparent for many of the samples. Overall, the MBA samples show a high degree of variability, whereas the LBA jars appear more standardized. This suggests production of the MBA jars was more varied, probably due to the manufacture of vessels at ports when products arrived for shipment. The vessel form shows only minimal adaptations from local storage containers for the purpose of ship transport. On the other hand, the LBA jars appear to have been more consistently produced probably on a regular basis at several port workshops specializing in Canaanite jar manufacture. Additionally, the form of the jar changed to be more conducive to transport by ship (e.g., handles placed higher on an angular shoulder and a more tapering body with a pointed base). Given that the MBA jars examined covered a shorter period (roughly 200 years), while the LBA jars encompassed a longer time span (roughly 500 years), the increased uniformity in the raw materials used to produce the latter vessesl is remarkable. This standardization was probably a result of the increased trade in Canaanite jars in the LBA and seems to indicate specialized production of LBA Canaanite jars, whereas the MBA vessels were produced on a more irregular basis[207]. Thus, the changes in trade in the LBA affected the production technology of these vessels.

## *8.4 Scientific Analyses of Ceramics to Understand Trade and Politics*

This study has aimed to integrate the results of the scientific analyses of ceramics with both archaeological data on the vessels and information on the political context in which the vessels were traded. Many studies employing petrographic and compositional data from ceramics do not relate the results to the appearance of the fabric or the shape of vessels. This yields interpretations that do not take full advantage of the available ceramic information. However, by analyzing samples taken from known vessel types and based on a fabric classification system, the results of the scientific investigations can be better integrated. In this study, the connection between fabric and provenance enabled sherds not analyzed to

[207] For ceramic standardization as evidence of specialization see case studies of Blackman *et al*. 1993 and Sinopoli 1993.

contribute valuable information on the frequency of importation for particular periods (successful only for the LBA jars). The shape of several jar rims was correlated with suggested provenances, thus allowing examination of spatial and chronological changes in vessel form. These results provide a basis for characterizing additional ceramic material without examining every piece scientifically.

The identification of areas exporting goods from the Levant to Egypt enabled an examination of the influence of politics on trade, and the affect of trade on political developments between the two areas for two periods. During the late MBA, the political division of Egypt between Levantine rulers in the north and Egyptians in the south did not prevent trade with the Levant from occurring. On the contrary, the establishment of a virtual trading diaspora in the Eastern Delta seems to have encouraged trade with this area. However, as a result of this political situation, Egyptians outside of the Delta, for the most part, had limited access to imported goods. Further, the archaeological evidence suggests the Delta-based MBA Levantine culture was virtually non-existent outside this area. Rather, during the Second Intermediate Period, both Memphis and other areas in Egypt developed their own cultural traditions (Bader 2009; Bourriau in press). Thus, contact between Egyptians and the mixed Egyptian-Levantine populations appears to have been limited; trade with the Levant was carried out predominantly for the benefit of those living in the Delta.

The regions in the Levant engaged in trade with Egypt were probably based largely on areas that could supply desired products, had coastal locations with ports, and had the resources to organize the shipment of goods. However, the presence of the Levantine population in Egypt also clearly influenced which regions participated in trade with Egypt, as they apparently had demand for particular products from specific areas. These were principally the regions of Lebanon and the coastal plain of Palestine. As there is little evidence for Hyksos control of these regions (Oren 1997), the movement of Cananaite jars must have been facilitated by trade "agreements" between the mixed population in the Eastern Delta and cities in the Levant. In fact, as the Hyksos came to power, the importation of Canaanite jars to Tell el-Dab$^{c}$a declined (Kopetzky 2004: 276; Aston 2004a: 239). This may have been the result of the beginning of political disruptions in the northern Levant. However, if most of the imports coming to Tell el-Dab$^{c}$a in the 12$^{th}$ and 13$^{th}$ Dynasties were acquired by Egyptian rulers, their withdrawl from northern Egypt may have played a role in the decline of imports. Therefore, during the MBA, demand from individual sites seems to have been paramount, while political changes may have also affected trade networks.

In the LBA, the political unity of Egypt and its control of the regions exporting commodities were clearly influential. However, the change in participants in international trade suggests a more complicated relationship between trade and politics. While Egypt had control over the coastal regions of Lebanon and Palestine, not all of these areas exported commodities to Egypt, only those with desired goods. The paucity of exported commodities from southern Palestine, a region of clear interest to the Egyptians, illustrates that specific product demand was more important than ease of access to areas producing goods. Further, arguments about the economic benefit of southern Palestine to Egypt seem unfounded, at least in terms of commodities transported in Canaanite jars. The region may instead have served as a buffer zone and access point for the Egyptians (Hoffmeier 1989, 1990, 1991, 2004). This may suggest that Egyptian rulers destroyed sites in the area to subdue the local population as maintenance of sites for acquiring goods was not necessary. Thus, political goals may have been more important to the Egyptians than access to goods from southern Palestine.

Other political disruptions in the LBA seem to have terminated the movement of commodities from certain areas on the one hand (i.e. the possible export of goods from Byblos only in the MBA) and not on another (continued export of products from the Akkar Plain and Ugarit despite political upheaval). While in the MBA cities trading with Egypt were probably doing so on a cooperative basis, in the LBA the willingness of towns under Egyptian control to export goods is difficult to determine. The economic benefit to cities within the Egyptian empire exporting commodities in Canaanite jars is also problematic to assess, as goods may have also reached Egypt through tribute, in which case the economic gain to the cities was probably negligible. However, the economic benefits of trade clearly played a role in bringing certain areas, such as Cyprus, into the Eastern Mediterranean network. Examination of Cypriot pottery in the Levant based on provenance and amount revealed that contacts between these areas were at their greatest from 1400 to 1200 BC (Artzy 1985). This coincides with an increase in the numbers of Canaanite jars at Memphis, suggesting that this era represented the peak in organized and consistent trade within the Eastern Mediterranean (Fig. 8.1; Sherrat and Sherrat 1991: 372; Manning and Hulin 2005: 279). However, trade in the LBA was not just in commodities in Canaanite jars, but was now focussed on the movment of copper and tin for producing bronze, along with high value items of glass, gold, silver, and wood. The economic benefit to polities involved in trade of such magnitude clearly influenced and defined LBA interaction. Overall, while less trade was probably carried out in the MBA, the two periods were similar in that trade influenced the creation of powerful entities (the Hyksos in the MBA; Egyptians and other empires in the LBA). Conversely, as seen with the Hyksos dynasty in the Nile Delta and the change in materials in the LBA, political situations clearly affected trade, including which areas exported goods to Egypt.

The integration of data from ceramics with information on the political context of trade has highlighted the complex dynamic between trade and politics. Political situations can greatly influence the ability to conduct trade and the individuals involved. Changes in political configuration obviously affected not just the partners in the trading network but also the production of vessels employed to carry the desired commodities. However, particularly in the LBA, the economic benefits of controlling trade appear to have been a key factor in determining which political entities controlled specific areas. For example, the contested Akkar Plain, providing direct access to inland empires, seems to best illustrate the desire to control areas that were engaged in lucrative trade. These results substantiate that provenance studies should go beyond the identification of producer and consumer, and should aim to provide a more refined understanding of the context of trade and the influences of politics on interregional networks.

### *8.5 Future Research*

The approaches utilized in this study can be readily expanded and applied to investigations of trade relations throughout the Eastern Mediterranean. For example, scientific analyses of additional MBA and LBA Canaanite jars would place them into the now refined context of trade between Egypt and the Levant. Analysis of the MBA Canaanite jars at the site of Lisht, close to the Middle Kingdom royal residence, would reveal which regions may have exported goods to the royal court during the 12th and early 13th Dynasties (Arnold *et al*. 1993). Further, analysis of the recently discovered MB IIA Canaanite jar sherds from Mersa/Wadi Gawasis on the Red Sea Coast would clarify the movement of these vessels from the Levant and within Egypt (Bard & Fattovich 2009: 47, 51, Fig. 27)[208]. Examination of the LBA Canaanite jars at ‘Ezbet Helmi near Tell el-Dab$^{c}$a could reveal the jars imported to the Delta in the 18th Dynasty and if there are differences from those found at Memphis and Amarna (Fuscaldo 2001: 158; Aston 2004a: 176-178)[209]. This is especially important in light of the lack of Canaantie jars from southern Palestine in the LBA levels at

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[208] I wish to thank Prof. Bietak for providing this suggestion.

[209] Preliminary macroscopic examination of these jars by the author while at Tell el-Dab$^{c}$a suggested similarities to the Memphis and Qantir vessels.

Memphis. Initial macroscopic investigations have revealed similarities between some of the LBA Canaanite jars from the 19th Dynasty capital at Piramesses/Qantir in the eastern Nile Delta and those from Memphis. However, as noted by Aston (1998: 69-72, 627-677), other fabrics from jars at Memphis may not be comparable to those at Qantir. Scientific studies would clarify any differences in importation between Memphis and Qantir, and confirm which areas were significant exporters to Egypt during the 19th Dynasty.

The study of MBA and LBA Canaanite jars in the Levant would greatly assist in the determination of the extent to which these vessels were traded within the region. Particularly at sites that may have been producing the jars, analyses could make a link between the provenance of the vessel and its form, along with chronological changes in manufacturing processes and shape characteristics. Analysis of imported LBA Canaanite jars on Cyprus would provide important information on the major trading partners for this significant area. Based on analysis of trade between the Levant and Cyprus during the LBA to Iron Age transition, the possibility exists that the northern half of Cyprus traded with Syria and Turkey, while the southern half of Cyprus traded with Lebanon and Palestine (Bell 2006). Petrographic analysis of Canaanite jars from Maa-*Paleokastro*, Kalavasos-*Ayios Dhimitrios*, Hala Sultan Tekke, and Enkomi would generate the necessary data to test this hypothesis and examine any changes in trade patterns over time. Similarily, analysis of LBA Canaanite jars in Greece, on Crete[210], and at the site of Zawiyet Umm el-Rakham (N. Libya) would greatly clarify how these vessels moved around the Eastern Mediterrnean and whether certain areas only received commodities from specific localities. As Canaanite jars are archaeologically visible indicators of trade, their continued study can only enhance our knowledge of the importance of trade to the ancient societies of the Eastern Mediterranean.

[210] Some work on LBA Canaantie jars from Kommos has been carried out by Dr. Peter Day and Dr. Patrick Quinn.

# Bibliography

*Journal Abbreviations:*
AJA, American Journal of Archaeology
ASAE, Annales du service des antiquités de l'Égypte
BASOR, Bulletin of the American Schools of Oriental Research
JAS, Journal of Archaeological Science
JEA, The Journal of Egyptian Archaeology
JSSEA, Journal of the Society for the Study of Egyptian Antiquities
IEJ, Israel Exploration Journal
MDAIK, Mitteilungen des Deutschen Archäologischen Instituts, Abteilung Kairo

Abd el-Maqsoud, M., 1998. *Tell Heboua (1981-1991): Enquête archéologique sur la Deuxième Période Intermédiaire et le Nouvel Empire à l'extrémité orientale du Delta*, Paris: Ministère des affaires étrangères, Éditions Recherche sur les civilisations.

Adams, R.McC., 1974. Anthropological perspectives on ancient trade. *Current Anthropology*, 15, 239-58.

Ahituv, S., 1978. Economic Factors in the Egyptian Conquest of Canaan. *IEJ*, 28, 93-105.

Ahrens, A., 2006. A Journey's End – Two Egyptian Stone Vessels with Hieroglyphic Inscriptions from the Royal Tomb at Tell Mišrife/Qatna. *Ägypten und Levante*, XVI, 15-36.

Åkerström, Å., 1975. More Canaanite Jars from Greece. *Opuscula Atheniensia*, 11, 185-192.

Al-Dayel, O., 1995. *Characterization of Egyptian Ceramics by Neutron Activation Analysis*. Unpublished Ph.D. Dissertation, University of Manchester.

Albright, W., 1936. The Excavation of Tell Beit Mirsim. Vol. II: The Bronze Age. *The Annual of the American Schools of Oriental Research*, 17, xi-141.

Albright, W., 1966. Remarks on the Chronology of Early Bronze IV-Middle Bronze IIA in Phoenicia and Syria- Palestine. *BASOR*, 184, 26-35.

Algaze, G., 1993. *The Uruk world system: the dynamics of expansion of early Mesopotamian civilization*, Chicago: University of Chicago Press.

Allaby, A. & Allaby, M., 2003. *Oxford Dictionary of Earth Sciences*, Oxford: Oxford University Press.

Allen, J., 2008. The Historical Inscription of Khnumhotep at Dahshur: Preliminary Report. *BASOR*, 352, 29-39.

Altenmüller, H. & Moussa, A., 1991. Die Inschrift Amenemhets II. aus dem Ptah- Tempel von Memphis. Ein Vorbericht. *Studien zur Altägyptischen Kultur*, 18, 1-48.

Amiran, R., 1960. The Pottery of the Middle Bronze Age I in Palestine. *IEJ*, 10, 204-225.

Amiran, R., 1970. *Ancient Pottery of the Holy Land*, New Brunswick: Rutgers University Press.

Anati, E., 1959. Excavations at the Cemetery of Tell Abu Hawam (1952). *'Atiqot*, 2, 89-101.

Anthes, R., 1959. *Mit Rahineh 1955*, Philadelphia: University Museum, University of Pennsylvania.

Anthes, R., 1965. *Mit Rahineh 1956*, Philadelphia: University Museum, University of Pennsylvania.

Armstrong, J. & Warburton, D. eds., 2000. *Just in Time. Proceedings on the International Colloquium on Ancient Near Eastern Chronology (2nd Millennium BC)*, Brussels: Fondation Assyriologique George Dossin.

Arnold, D.E., 1985. *Ceramic theory and cultural process*, Cambridge: Cambridge University Press.

Arnold, Do., 1982. Keramikbearbeitung in Dahschur 1976-1981. *MDAIK*, 38, 25-65.

Arnold, Do., 1988. Pottery. In Di. Arnold, ed. *The South Cemeteries of Lisht I: The Pyramid of Senwosret I.* New York: Metropolitan Museum of Art, pp. 106-146.

Arnold, Do., Arnold, F. & Allen, S., 1993. Canaanite Imports at Lisht, The Middle Kingdom Capital of Egypt. *Ägypten und Levante,* V, 13-32.

Artzy, M., 1985. Supply and Demand; a study of second millennium Cypriote pottery in the Levant. In A.B. Knapp & T. Stech, eds. *Prehistoric Production and Exchange: The Aegean and the Eastern Mediterranean*. Los Angeles: Cotsen Institute of Archaeology, UCLA, pp. 93-99.

Artzy, M., 1993. Tel Nami. In E. Stern, A. Lewison-Gilboa & J. Aviram, eds. *The New Encyclopaedia of Archaeological Excavations in the Holy Land, Vol. 3.* London: Simon & Schuster, pp. 1095-1098.

Artzy, M., 2007. Tell Abu Hawam: News from the Late Bronze Age. In M. Bietak & E. Czerny, eds. *The Synchronisation of Civilisations in the Eastern Mediterranean in the Second Millennium B.C. III. Proceedings of the SCIEM 2000 – 2nd EuroConference, Vienna, 28th of May – 1st of June 2003*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 357-366.

Artzy, M. & Asaro, F., 1979. Origin of Tell el-Yahudiyah Ware Found in Cyprus. *Report of the Department of Antiquities Cyprus*, 135-150.

Aruz, J., 1993. Imagery and Interconnections. *Ägypten und Levante*, V, 33-48.

Ashton, S.-A. & Hughes, M., 2005. Large, Late and Local? Scientific Analysis of Pottery Types from Al Mina. In A. Villing, ed. *The Greeks in the East*. British Museum Research Publication No. 157. London: British Museum Press, pp. 93-103.

Aston, B.G., 2005. The Pottery. In M.J. Raven, ed. *The tomb of Pay and Raia at Saqqara*. London: Egypt Exploration Society, pp. 94-128.

Aston, D.A., 1991. The Pottery. In M.J. Raven, ed. *The tomb of Iurudef: a memphite official in the reign of Ramesses II*. London: Egypt Exploration Society, pp. 47-54.

Aston, D.A., 1996. Tell Hebwa IV – Preliminary Report on the Pottery. *Ägypten und Levante,* VI, 179-198.

Aston, D.A., 1997. The Pottery. In G.T. Martin, ed. *The Tomb of Tia and Tia*. London: Egypt Exploration Society, pp. 83-102.

Aston, D.A., 1998. *Qantir I. Die Keramik des Grabungsplatzes Q1. Teil 1. Corpus of Fabrics, Wares, and Shapes*, Mainz am Rhein: Verlag Phillip von Zabern.

Aston, D.A., 1999. *Pottery from the late New Kingdom to the Early Ptolemaic Period. Elephantine XIX*. Deutsches Archäologisches Institut. Abteilung Kairo. Archäologische Veröffentlichungen 95. Mainz am Rhein: Verlag Phillip von Zabern.

Aston, D.A., 2002. Ceramic Imports at Tell el-Dab$^{c}$a during the Middle Bronze IIA. In M. Bietak, ed. *The Middle Bronze Age in the Levant, Proceedings of an International Conference on MB IIA Ceramic Material, Vienna, 24-26th of January 2001, CChEM 3*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 43-87.

Aston, D.A., 2004a. *Tell el-Dab$^{c}$a XII: A Corpus of Late Middle Kingdom and Second Intermediate Period Pottery,* Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Aston, D.A., 2004b. Amphorae in New Kingdom Egypt. *Ägypten und Levante*, XIV, 175-213.

Aston, D.A., 2004c. Book Review: The Foreign Relations of the "Hyksos". A neutron activation study of Middle Bronze Age pottery from the Eastern Mediterranean, by P.E. McGovern, BAR International Series 888, Oxford, Archeopress, 2000. *JEA*, 90, 233-237.

Aston, D.A., 2008. A History of Tell el-Yahudiyeh Typology. In M. Bietak & E. Czerny, eds. *The Bronze Age in the Lebanon. Studies on the Archaeology and Chronology of Lebanon, Syria, and Egypt*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 165-194.

Aston, D.A. & Aston, B.G., 2001. The Pottery. In G.T. Martin, ed. *The tombs of three Memphite officials*. *Ramose, Khay and Pabes*. London: Egypt Exploration Society, 50-61.

Aston, D.A. & Jeffreys, D.G., 2007. *Excavations at Kom Rabia (Site Rat): post-Ramesside levels and pottery. Survey of Memphis III*, London: Egypt Exploration Society.

Aston, D.A., Aston, B.G., & Brock, E.C., 1998. Pottery from the Valley of the Kings – Tombs of Merenptah, Ramesses III, Ramesses IV, Ramesses VI and Ramesses VII. *Ägypten und Levante*, VIII, 137-214.

Åström, P., 1986. Hala Sultan Tekke and its Foreign Relations. In V. Karageorghis,ed. *Acts of the International Archaeology Symposium "Cyprus between the Orient and the Occident"*. Nicosia: Department of Antiquities, Cyprus, pp. 63-68.

Åström, P., 1991a. Canaanite Jars from Hala Sultan Tekke. In N.H. Gale, ed. *Bronze Age Trade in the Mediterranean*. Studies in Mediterranean Archaeology 90. Jonsered: Paul Åströms Förlag, pp. 149-151.

Åström, P., 1991b. Problems of Definition of Local and Imported Fabrics of Late Cypriot "Canaanite" Ware. In J.A. Barlow, D. Bolger, & B. Kling, eds. *Cypriot Ceramics: Reading the Prehistoric Record*. University Museum Monograph 74 Philadelphia: University of Pennsylvania Museum, pp. 67-72.

Badawi, A., 1948. *Memphis als Zweite Landeshauptstadt im Neuen Reich*, Le Caire: Institut Français d'Archéologie Orientale.

Bader, B., 2001. *Tell el-Dab^c^a XIII. Typologie und Chronologie der Mergel C-Ton Keramik. Materialien zum Binnenhandel des Mittleren Reiches und der Zweiten Zwishenzeit*, Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Bader, B., 2002. A Concise Guide to Marl C Pottery. *Ägypten und Levante*, XIII, 29-54.

Bader, B., 2003. The Egyptian jars from Sidon in their Egyptian context: a preliminary report. *Archaeology and History in Lebanon*, 18, 31-37.

Bader, B., 2007. A Tale of Two Cities: First Results of a Comparison Between Avaris and Memphis. In M. Bietak & E. Czerny, eds. *The Synchronization of Civilizations in the Eastern Mediterranean in the Second Millennium B.C. II, Vol. III*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 249-267.

Bader, B., 2008. Avaris and Memphis in the Second Intermediate Period in Egypt (ca. 1770-1550/40 BC). In J. Córdoba, M. Molist, C. Pérez, I. Rubio & S. Martínez, eds. *Proceedings of the 5th International Congress on the Archaeology of the Ancient Near East, Madrid, April 3-8, 2006*. Madrid: Centro Superior de Estudios sobre el Oriente Próximo y Egipto, pp. 207-223.

Bader, B., 2009. *Tell el-Dab^c^a XIX. Aurais und Memphis Im Mittleren Reich Und in Der Hyksoszeit. Vergleichsanalyse Der Materiellen Kultur*, Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Bader, B., in press. Traces of foreign settlers in the Archaeological Record of Tell el-Dab^c^a. In *Proceedings of the Conference Intercultural Contacts in the Ancient Mediterranean*.

Badre, L., 1997. Excavations of the American University of Beirut Museum 1993-1996. *Bulletin d'Archéologie et d'Architecture Libanaises*, 2.

Badre, L. & Gubel, É., 1999-2000. Tell Kazel, Syria. Excavations of the AUB Museum, 1993-1998. Third Preliminary Report. *Berytus*, 44, 123-203.

Badre, L., Boileau, M.-C., Jung, R., & Mommsen, H., 2005. The Provenance of Aegean- and Syrian-Type Pottery Found at Tell Kazel (Syria). *Ägypten und Levante*, XV, 15-47.

Badre, L., Gubel, É., Capet, E., & Panayot, N., 1994. Tell Kazel (Syrie), Rapport préliminaire sur les 4e-8e campagnes de fouilles (1988-1992). *Syria*, 71, 259-346.

Bagh, T., 1998. ʻEzbet Rushdi and the 12th Dynasty Levantine Connection. *Ägypten und Levante*, VIII, 47-49.

Balensi, J., Herrera, M.D., & Artzy, M., 1993. Tell Abu Hawam. In E. Stern, A. Lewison-Gilboa & J. Aviram, eds. *The New Encyclopaedia of Archaeological Excavations in the Holy Land, Vol. 1*. London: Simon & Schuster, pp. 7-14.

Bard, K.A. and Fattovich, R., 2009. *Mersa/Wadi Gawasis, Mission 2007-2008*. Online at: www.archeogate.org.

Barra Bagnasco M., Casoli, A., Chiari, G., Compagnoni, R., Davit, P., & Mirti, P., 2001. Mineralogical and chemical composition of transport amphorae excavated at Locri Epizephiri (southern Italy). *Journal of Cultural Heritage*, 2, 229−239.

Barraclough, A., 1992. Quaternary sediment analysis: a deductive approach at A-level. *Teaching Geography*, 17, 15-18.

Bartov, Y., 1994. *Geological Photomap of Israel and Adjacent Areas, 1:750,000, 2nd Ed.*, Jerusalem: The Geological Survey.

Bass, G.F., 1973. Cape Gelidonya and Bronze Age Maritime Trade. In H. A. Hoffner, ed. *Orient and Occident: Essays presented to Cyrus H. Gordon on the occasion of his sixty-fifth birthday*. Kevelaer: Butzon & Bercker, pp. 29-38.

Bass, G.F., 1986. A Bronze Age Shipwreck at Ulu Burun (Kaş): 1984 Campaign. *AJA*, 90, 269-96.

Baxter, M., 2001. Multivariate Analysis in Archaeology. In D.R. Brothwell & A.M. Pollard, eds. *Handbook of Archaeological Sciences*. Chichester: John Wiley & Sons, Ltd, pp. 685-694.

Baxter, M., 2003. *Statistics in Archaeology*, London: Hodder Arnold.

Baxter, M. & Freestone, I.C., 2006. Log-Ratio Compositional Data Analysis in Archaeometry, *Archaeometry*, 48(3), 511-531

Baxter, M. & Jackson, C.M., 2001. Variable Selection in Artefact Compositional Studies. *Archaeometry*, 43(2), 253-268.

Beck, P., 1975. The Pottery of the Middle Bronze Age IIA at Tel Aphek. *Tel Aviv*, 2, 45-85.

Beck, P., 1985. The Middle Bronze Age IIA Pottery from Aphek, 1972-1984; First Summary. *Tel Aviv*, 12, 181-203.

Beck, P., 2000. Area B: Pottery (Ch. 8) and Area A: Middle Bronze IIA Pottery (Ch. 10). In M. Kochavi, P. Beck, & E. Yadin, eds *Aphek-Antipatris I. Excavation of Areas A and B. The 1972-1976 Seasons*. Tel Aviv: Emery and Claire Yass Publications in Archaeology, Institute of Archaeology, Tel Aviv University, pp. 93-133 and 173-238.

von Beckerath, J., 1964. *Untersuchungen zur politischen Geschichte der Zweiten Zwischenzeit in Ägypten*, Glückstadt: J.J. Augustin.

von Beckerath, J., 1984. *Handbuch der ägyptischen Königsnamen*, München: Deutscher Kunstverlag.

von Beckerath, J., 1997. *Chronologie des pharaonishen Ägypten: die Zeitbestimmung der ägyptischen Geschichte von der Vorzeit bis 332 v. Chr.*, Mainz am Rhein: Verlag Phillip von Zabern.

Beckman, G., 1996. *Hittite Diplomatic Texts*, Atlanta: Scholars Press.

Beier, T. & Mommsen, H., 1994. Modified Mahalanobis Filters for Grouping Pottery by Chemical Composition. *Archaeometry*, 36(2), 287-306.

Bell, C., 2006. *The Evolution of Long Distance Trading Relationships across the LBA/Iron Age Transition on the Northern Levantine Coast: Crisis, continuity and change*. Bar International Series 1574. Oxford: Archaeopress.

Bennet, C., 2006. Genealogy and the Chronology of the Second Intermediate Period. *Ägypten und Levante*, XVI, 231-244.

Ben-Arieh, S., 2004. *Bronze and Iron Age Tombs at Tell Beit Mirsim*. Israel Antiquities Authority Reports 23. Jerusalem: Israel Antiquities Authority.

Ben-Arieh, S. & Edelstein, G., 1977. Akko: Tombs near the Persian Garden. The Tombs and their Contents. *'Atiqot*, 12, 1-44.

Ben-Tor, A., ed., 1989. *Hazor III-IV: The James A. de Rothschild Expadition to Hazor. An Account of the Third and Fourth Seasons of Excavations 1957–1958*, Jerusalem: Israel Exploration Society.

Ben-Tor, A., 2006a. The Sad Fate of Statues and the Mutilated Satues of Hazor. In S. Gitin, J.E. Wright, & J.P. Dessel,eds. *Confronting the Past: Archaeological and Historical Essays on Ancient Israel in Honor of William G. Dever*. Winona Lake, IN: Eisenbrauns, pp. 3-16.

Ben-Tor, A., 2006b. Do the Excecration Texts Reflect an Accurate Picture of the Contemporary Settlement Map of Palestine? In Y. Amit, ed. *Essays on Ancient Israel in its Near Eastern Context: a Tribute to Nadav Na'aman*. Winona Lake, IN: Eisenbrauns, pp. 63-87.

Ben-Tor, A., 2005. Hazor and Chronology. *Ägypten und Levante*, XIV, 45-67.

Ben-Tor, A. & Bonfil, R., eds., 1997. *Hazor V: The James A. de Rothschild Expedition to Hazor. Account of the Fifth Season of Excavations 1968*, Jerusalem: Israel Exploration Society.

Ben-Tor, D., 1994. The Historical Implications of Middle Kingdom Scarabs Found in Palestine Bearing Private Names and Titles of Officials. *BASOR*, 294, 7-22.

Ben-Tor, D., 1998. The Absolute Date of the Montet Jar Scarabs. In L.H. Lesko, ed. *Ancient Egyptian and Mediterranean Studies in Memory of William A. Ward*. Providence: Department of Egyptology, Brown University, pp. 1-17.

Ben-Tor, D., 2004. Second Intermediate Period Scarabs from Egypt and Palestine: Historical and Chronological Implications. In M. Bietak & E. Czerny, eds. *Scarabs of the Second Millennium BC from Egypt, Nubia, Crete, and the Levant: Chronological and Historical Implications. Papers of a Symposium, Vienna, 10th – 13th of January 2002*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 27-42.

Ben-Tor, D., 2007a. *Scarabs, Chronology and Interconnections: Egypt and Palestine in the Second Intermediate Period*, Friboug-Gottingen: Academic Press Fribourg, Vandenhoeck & Ruprecht.

Ben-Tor, D., 2007b. Scarabs of the Middle Kingdom Historical and Cultural Implications. *Bulletin of the Egyptological Seminar*, 17, 3-27.

Ben-Tor, D., 2009. Can Scarabs Argue for the Origin of the Hyksos? *Journal of Ancient Egyptian Interconnections*, 1(1), 1-7.

Ben-Tor, D., Allen, S. & Allen, J., 1999. Review: Seals and Kings. Review of "The Political Situation in Egypt during the Second Intermediate Period c. 1800-1550 B. C. by K. S. B. Ryholt". *BASOR*, 315, 47-74.

Beydoun, Z.R., 1976. Observations on Geomorphology, Transportation and Distribution of Sediments in Western Lebanon and its Continental Shelf and Slope Regions. *Marine Geology*, 21, 311-324.

Beydoun, Z.R., 1977. The Levantine countries: the geology of Syria and Lebanon (maritime regions). In A.E.M. Nairn, W.H. Kanes, & F.G. Stehli, eds. *The ocean basins and margins. 4A: The eastern Mediterranean*. Plenum Press: New York and London, pp. 319-353.

Bienkowski, P., 1989. The Division of the Middle Bronze IIB-C in Palestine. *Levant*, 13, 169-179.

Bietak, M., 1987. Canaanites in the Eastern Nile Delta. In A. Rainey, ed. *Egypt, Israel, Sinai: Archaeological and Historical Relationships in the Biblical Period*. Tel Aviv: Tel Aviv University, pp. 41-56.

Bietak, M., 1989a. Archäologischer Befund und historische Interpretation am Beispiel der Tell el-Yahudiya-Ware. In S. Schoske, ed. *Akten des vierten Internationalen Ägyptologen-Kongresses, München 1985*. Studien zur Altägyptischen Kultur, Beiheft Band. Hamburg: Buske, pp. 7-34.

Bietak, M., 1989b. Servant Burials in the Middle Bronze Age Culture of the Eastern Nile Delta. *Eretz-Israel,* 20, 30*-43*.

Bietak, M., 1991a. Egypt and Canaan during the Middle Bronze Age. *BASOR*, 281, 27-72.

Bietak, M., 1991b. *Tell el-Dab$^{c}$a V: ein Friedhofsbezirk der Mittleren Bronzezeitkultur mit Totentempel und Siedlungsschichten*, Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Bietak, M., 1993. The Seapeoples and the End of the Egyptian Administration in Canaan. In A. Biran & J. Aviram, eds. *Biblical archaeology today, 1990: proceedings of the Second International Congress on Biblical Archaeology, Jerusalem, June-July 1990*. Jerusalem: Israel Exploration Society, pp. 299-306.

Bietak, M., 1996. *Avaris, the Capital of the Hyksos. Recent Excavations at Tell el-Dab$^{c}$a*, London: British Museum Press.

Bietak, M., 2001. Hyksos. In D.B. Redford, ed. *The Oxford Encyclopedia of Ancient Egypt, vol. II*. Oxford: Oxford University Press, pp. 136-143.

Bietak, M., 2002. Relative and Absolute Chronology of the Middle Bronze Age: Comments on the Present State of Research. In M. Bietak, ed. *The Middle Bronze Age in the Levant, Proceedings of an International Conference on MB IIA Ceramic Material, Vienna, 24-26th of January 2001, CChEM 3*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 29-42.

Bietak, M., 2007a. Egypt and the Levant. In T. Wilkinson, ed. *The Egyptian World*. London: Routledge, pp. 417-448.

Bietak, M., 2007b. Towards a Middle Bronze Age of the Levant. In P. Matthaie, L. Nigro, L. Peyronel, & F. Pinnock, eds. *Proceedings of the International Colloquium From Relative Chronology to Absolute Chronology: The Second Millennium BC in Syria Palestine*. Rome: Accademia Nazionale dei Lincei, pp. 121-146.

Bietak, M., in press. From where came the Hyksos and where did they go?. In M. Marée, ed. *The Second Intermediate Period (Thirteenth – Seventeenth Dynasties): Current Research, Future Prospects*. OLA 192. Leuven: Peeters.

Bietak, M. & Höflmayer, F., 2007. Introduction: High and Low Chronology. In M. Bietak & E. Czerny, eds. *The Synchronization of Civilizations in the Eastern Mediterranean in the Second Millennium B.C. II, Vol. III*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 13-23.

Bietak, M., Forstner-Müller, I. & Mlinar, C., 2001. The Beginning of the Hyksos Period at Tell el Dab'a: A Subtle Change in Material Culture. In P. Fischer, ed. *Contributions* *to the Archaeology and History of the Bronze and Iron Ages in the Eastern Mediterranean. Studies in Honour of Paul Åström*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 171-181.

Bietak, M., Kopetzky, K., Stager, L.E., & Voss, R., 2008. Synchronisation of Stratigraphies: Ashkelon and Tell el-Dab$^{c}$a. *Ägypten und Levante*, XVIII, 49-60.

Bikai, P., 1978. *The Pottery of Tyre*, Warminster: Aris and Phillips.

Bishop, R.L. & Neff, H., 1989. Compositional Data Analysis in Archaeology. In R.O. Allen, ed. *Archaeological Chemistry IV*. Washington D.C.: American Chemical Society, pp. 57-86.

Bishop, R.L., Canouts, V., Crown, P.L., & De Atley, S.P., 1990. Sensitivity, precisions and accuracy: their roles in ceramic compositional data bases. *American Antiquity*, 55 (3), 537-546.

Bishop, R.L., Rands, R.L.,& Holley, G.R., 1982. Ceramic compositional analysis in archaeological perspective. In M.B. Schiffer, ed. *Advances in Archaeological Method and Theory 5*. New York: Academic Press, pp. 275-330.

Bisson de la Roque, M., 1927. *Rapport sur Les Fouilles de Médamoud (1926). 1er pt*, Le Caire: Institut Français d'Archéologie Orientale.

Bisson de la Roque, M., 1950. *Le trésor de Tôd*, Le Caire: Institut Français d'Archéologie Orientale.

Bisson de la Roque, M., Contenau, G. & Chapouthier, F., 1953. *Le trésor de Tôd*, Le Caire: Institut Français d'Archéologie Orientale.

Blackman, A., 1915. *The Rock Tombs at Meir III*, London: Egypt Exploration Fund.

Blackman, J.M., Stein, G.J., & Vandiver, P.B., 1993. The Standardization Hypothesis and Ceramic Mass Production: Technological, Compositional, and Metric Indexes of Craft Specialization at Tell Leilan, Syria. *American Antiquity*, 58 (1), 60-80.

Bomgardner, D.L., 1981. Atomic Absorption Spectroscopy Applications for Ceramic Analysis. In M.J. Hughes, ed. *Scientific Studies in Ancient Ceramics*. British Museum Occasional Paper No. 19. London: British Museum Press, pp. 93-101.

Bonechi, M., 1992. Relationes amicales Syro-Palestiniennes: Mari et Hazor au XVIIIe siècle av. J.C. In J.M. Durand, ed., *Memoires de N.A.B.U. 1, Florilegium Marianum. Recueil d'études en l'honneur de Michel Fleury*. Paris: Société pour l'étude du Proche-Orient Ancienne, pp. 9–22.

Boulton, N. & Heron, C., 2000. The Chemical Detection of Ancient Wine. In P.T. Nicholson & I. Shaw, eds. *Ancient Egyptian Materials and Technology*. Cambridge: Cambridge University Press, pp. 599-602.

Bourke, S. J., 1993. The transition from the Middle to the Late Bronze Age in Syria: the evidence from Tell Nebi Mend. *Levant*, 25, 155-195.

Bourke, S.J., 2002. Book Review: The Foreign Relations of the "Hyksos". A neutron activation study of Middle Bronze Age pottery from the Eastern Mediterranean, by Patrick E. McGovern. *BASOR*, 326, 90-94.

Bourriau, J., 1986. Kôm Rabî'a (Egypt Exploration Society: Memphis Excavations 1986). *Bulletin de Liaison due Groupe International d'Étude de la Céramique Égyptienne*, XI, 22-23.

Bourriau, J., 1987. Kôm Rabî'a, Memphis (Egypt Exploration Society). *Bulletin de Liaison due Groupe International d'Étude de la Céramique Égyptienne*, XII, 10-11.

Bourriau, J., 1988. Kôm Rabî'a, Mit Rahina (The Egypt Exploration Society). *Bulletin de Liaison due Groupe International d'Étude de la Céramique Égyptienne*, XIII, 29-31.

Bourriau, J., 1990a. Memphis/ Kôm Rabî'a, 1990 (Egypt Exploration Society). *Bulletin de Liaison due Groupe International d'Étude de la Céramique Égyptienne*, XV, 17-18.

Bourriau, J., 1990b. Canaanite Jars from New Kingdom Deposits at Memphis, Kom Rabi'a. *Eretz-Israel*, 21, 18-26.

Bourriau, J., 1990c. The Pottery. In P. Lacovara, ed. *Deir el-Ballas. Preliminary Report on the Deir el-Ballas Expedition, 1980-1986*. ARCE Reports 12. Winona Lake, IN: Eisenbrauns for the American Research Center in Egypt.

Bourriau, J., 1991a. Memphis, Kôm Rabî'a, 1991 (Egypt Exploration Society). *Bulletin de Liaison due Groupe International d'Étude de la Céramique Égyptienne*, XVI, 13-15.

Bourriau, J., 1991b. The Memphis Pottery Project. *The Cambridge Archaeological Journal*, 2, 263-268.

Bourriau, J., 1991c. Relations between Egypt and Kerma during the Middle and New Kingdoms. In W. Davies, ed. *Egypt and Africa: Nubia from Prehistory to Islam*. London: British Museum Press, pp. 129-144.

Bourriau, J., 1992. Memphis, Kôm Rabî'a (Egypt Exploration Society). *Bulletin de Liaison due Groupe International d'Étude de la Céramique Égyptienne*, XVII, 19-20.

Bourriau, J., 1996b. Observation of the Pottery from Serabit el-Khadim. *Cahiers de recherches de l'institut de Papyrologie et d'Egyptologie de Lille*, 18, 19-32.

Bourriau, J., 1997. Beyond Avaris: The Second Intermediate Period in Egypt Outside the Eastern Delta. In E.D. Oren, ed. *The Hyksos: New Historical and Archaeological Perspectives*. Philadelphia: University of Pennsylvania Museum, pp. 161-182.

Bourriau, J., 1999. Some Archaeological Notes on the Kamose Texts. In A. Leahy & J. Tait, eds. *Studies on Ancient Egypt in Honour of H.S. Smith*. London: Egypt Exploration Society, pp. 43-48.

Bourriau, J., 2000. The Second Intermediate Period (c. 1650-1550 BC). In I. Shaw, ed. *The Oxford History of Ancient Egypt*. Oxford: Oxford University Press, pp. 185-217.

Bourriau, J., 2004. The Beginnings of Amphora Production in Egypt. In J. Bourriau & J. Phillips, eds. *Invention and Innovation: The Social Context of Technological Change 2, Egypt, the Aegean and the Near East, 1650-1150 BC.* Oxford: Oxbow Books, pp. 77-95.

Bourriau, J., In press. The relative chronology of the Second Intermediate Period: Problems in linking regional archaeological sequences. In M. Maree, ed. *The Second Intermediate Period (Thirteenth to Seventeenth Dynasties): Current Research, Future Prospects*. *Colloquium held at the British Museum, 2004*. Leuven: Peeters.

Bourriau, J. & Aston, D., 1985a. Kôm Rabî'a (Egypt Exploration Society: Memphis Excavations 1985). *Bulletin de Liaison due Groupe International d'Étude de la Céramique Égyptienne,* X, 19-20.

Bourriau, J. & Aston, D., 1985b. Pottery. In G.T. Martin, ed. *The Tomb Chapels of Paser and Ra'ia at Saqqara*. London: Egypt Exploration Society, pp. 32–55.

Bourriau, J. & Eriksson, K.O., 1997. A Late Minoan Sherd from an Early 18th Dynasty Context at Kom Rabi'a, Memphis. In J. Phillips, ed. *Ancient Egypt, the Aegean, and the Near East. Studies in Honour of Martha Rhoads Bell, Vol. I.* San Antonio: Van Siclen Books, pp. 95-120.

Bourriau, J. & French, P., 1984. Kôm Rabî'a, Excavations at Memphis 1984 (Egypt Exploration Society). *Bulletin de Liaison due Groupe International d'Étude de la Céramique Égyptienne,* IX, 12-13.

Bourriau, J. & Gallorini, C., in press. Pottery from Memphis, Kom Rabi'a. In A. Seiler & R. Schiestl, eds. *The Middle Kingdom Pottery Handbook.*

Bourriau, J. & Nicholson, P., 1992. Marl Clay Pottery Fabrics of the New Kingdom from Memphis, Saqqara and Amarna. *JEA*,78, 29-91.

Bourriau, J., Aston, D., Raven, M.J., & Van Walsem, R., 2005. *The Memphite Tomb of Horemheb, Commander-in-Chief of Tut'ankhamun III. The New Kingdom Pottery*, London: Egypt Exploration Society.

Bourriau, J., Bellido, A., Bryan, N., & Robinson, V., 2006. Egyptian Pottery Fabrics: A Comparison between NAA Groupings and the "Vienna System". In E. Czerny, I. Hein, H. Hunger, D. Melman, & A. Schwab, eds. *Timelines, Studies in Honour of Manfred Bietak, Vol. III*. Leuven: Uitgeverij Peeters en Departement Oosterse Studies, pp. 261-292.

Bourriau, J., Smith, L.M.V. & Nicholson, P., 2000. *New Kingdom Pottery Fabrics: Nile clay and mixed Nile/Marl clay fabrics from Memphis and Amarna,* London: The Egypt Exploration Society.

Bourriau, J., Smith, L.M.V. & Serpico, M., 2001. The Provenance of Canaanite Amphorae found at Memphis and Amarna in the New Kingdom. In A. Shortland, ed. *The Social Context of Technological Change. Egypt and the Near East, 1650-1550 B.C.* Oxford, pp. 113-146.

Bridges, E.M., 1997. *World Soils, 3rd Ed*, Cambridge: Cambridge University Press.

van den Brink, E. & Levy, T. eds., 2002. *Egypt and the Levant: interrelations from the 4th through the early 3rd millennium BCE*, London: Leicester University Press.

van den Brink, E., van Wesemael, B. & Dirksz, P., 1987. A Geo-Archaeological Survey in the North-Eastern Nile Delta, Egypt; the First Two Seasons, a Preliminary Report. *MDAIK*, 43, 7-15.

Bromund, R.H., Bower, N.W. & Smith, R.H., 1976. Inclusions in Ancient Ceramics: An Approach to the Problem of Sampling for Chemical Analysis. *Archaeometry*, 18, 218-221.

Brumfiel, E. & Earle, T., 1987. *Specialization, Exchange, and Complex Societies*, Cambridge: Cambridge University Press.

Bryan, B. M., 2000. The Eighteenth Dynasty before the Amarna Period (c. 1550-1352 BC). In I. Shaw, ed. *The Oxford History of Ancient Egypt*. Oxford: Oxford University Press, pp. 218-271.

Buchbinder, B., 1975. Stratigraphic significance of the alga *Amphiroa* in Neogene-Quaternary bioclastic sediments from Israel. *Israel Journal of Earth Sciences*, 24, 44-48.

Budka, J., 2006. The Oriental Institute Ahmose and Tetisheri Project at Abydos 2002-2004: The New Kingdom Pottery. *Ägypten und Levante*, XVI, 83-120.

du Buisson, M., 1928. *L'ancienne Qatna: ou, Les ruines d'el-Mishrifé au Nord-Est de Homs (Émèse); deuxième campagne de fouilles, 1927*, Paris: P. Geuthner.

du Buisson, M., 1935. *Le site archéologique de Mishrifé-Qaṭna*, Paris: E. de Boccard.

Bunimovitz, S. & Finkelstein, I., 1993. Pottery. In I. Finkelstein, S. Bunimovitz, & Z. Lederman, eds. *Shiloh: The Archaeology of a Biblical Site*. Tel Aviv: Emery and Claire Yass Publications in Archaeology, Institute of Archaeology, Tel Aviv University, pp. 81-195.

Buxeda i Garrigós, J., Cau Ontiveros, M.A., & Kilikoglou, V., 2003. Chemical Variability in Clays and Pottery from a Traditional Cooking Pot Production Village: Testing Assumptions in Pereruela. *Archaeometry*, 45(1), 1-17.

Callendar, G., 2002. The Middle Kingdom Renaissance (c. 2055-1650 BC). In I. Shaw, ed. *The Oxford History of Ancient Egypt*. Oxford: Oxford University Press, pp. 148-183.

Cecil, L.G., 2004. Inductively Coupled Plasma Emission Spectroscopy and Postclassic Petén slipped Pottery: An Examination of Pottery Wares, Social Identity and Trade. *Archaeometry*, 46(3), 385–404.

Clamer, C., 2004. Additional Late Bronze Age Pottery Assemblages, Section A: The Pottery from Levels P-2 and P-1 in Area P. In D. Ussishkin, ed. *The Renewed Archaeological Excavations at Lachish (1973-1994), Vol. III*. Tel Aviv: Emery and Claire Yass Publications in Archaeology, Institute of Archaeology, Tel Aviv University, pp. 1155-1235.

Cline, E.H., 1994. *Sailing the Wine-Dark Sea. International trade and the Late Bronze Age Aegean*, Oxford: Tempus Reparatum.

Cline, E.H., 2000. “Contested Peripheries” in World Systems Theory: Megiddo and the Jezreel Valley as a Test Case. *Journal of World-systems Research*, VI (1), 7-16.

Cogswell, J.W., Neff, H., & Glascock, M.D., 1996. The Effect of Firing Temperature on the Elemental Characterization of Pottery. *JAS*, 23, 283-287.

Cohen, S., 2002. *Canaanites, Chronologies and Connections: the Relationship of Middle Bronze IIA Canaan to Middle Kingdom Egypt*, Winona Lake, IN: Eisenbrauns.

Cohen-Weinberger, A., 1998. Petrographic Analysis of the Egyptian Forms from Stratum VI at Tel Beth-Shean. In S. Gitin, A. Mazar, & E. Stern, eds. *Mediterranean Peoples in Transition: Thirteenth to Early Tenth Centuries BCE*. Jerusalem: Israel Exploration Society, pp. 406-12.

Cohen-Weinberger, A. & Goren, Y., 2004. Levantine-Egyptian Interactions During the 12th to the 15th Dynasties based on the Petrography of the Canaanite Pottery from Tell el-Dab$^{c}$a. *Ägypten und Levante*, XIV, 69-100.

Cole, D.P., 1984. *Shechem I: The Middle Bronze IIB Pottery*. American Schools of Oriental Research Excavation Reports. Winona Lake, IN: Eisenbrauns.

Cornwall, I.W. & Hodges, H.W.M., 1964. Thin sections of British Neolithic pottery: Windmill Hill – a test site. *Bulletin of the Institute of Archaeology*, 4, 29-33.

Courtois, J.-C., 1981. *Alasia II. Les Tombes d’Enkomi, le Mobilier Funéraire (Fouilles C.F.-A. Schaeffer 1947-1965)*, Paris: Mission Archéologique d’Alasia.

Courtois, J.-C. & Courtois, L., 1978. Corpus céramique de Ras Shamra-Ugarit, Niveau Historique. Bronze Moyen et Bronze Récent. Deuxième partie. In C.F.A. Schaeffer, ed. *Ugaritica VII*. Paris: Librairie Orentaliste Paul Geuthner, pp. 191-370.

Cyganowski, C.J.K., 2003. *An Intersite Comparison of Middle Kingdom Lower Egyptian Marl C Fabric*. Unpublished MPhil thesis, University of Cambridge.

Czerny, E., 1999. *Tell el-Dab$^{c}$a IX. Eine Plansiedlung des frühen Mittleren Reiches*, Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Czerny, E., 2001. Ein früher Beleg für hwt-wʿrt auf einem Siegelabdruck aus Tell el-Dab<sup>c</sup>a. *Ägypten und Levante*, XI, 13-26.

Dan, Y., Raz, Z., Yaalon, D.H., & Koyumdjisky, H., 1975. *Soil Map of Israel, 1:500,000*, Jerusalem: Survey of Israel.

Daressy, G., 1906. Un poignard du temps des rois pasteurs. *ASAE*, 7, 115-120.

Davies, N. de G., 1903. *The Rock Tombs of El Amarna. Pt. 1. The tomb of Meryra*, London: Egypt Exploration Fund.

Davies, N. de G., 1905. *The Rock Tombs of El Amarna. Pt. 2. The tombs of Panhesy and Meryra II*, London: Egypt Exploration Fund.

Davies, N. de G., 1927. *Two Ramesside Tombs at Thebes*, New York: Metropolitan Museum of Art.

Davies, N. de G., 1930. *The tomb of Ḳen-Amūn at Thebes*, New York: Metropolitan Museum of Art.

Davies, N. de G., 1933. *Tombs of Menkheperrasonb, Amenmose, and another (Nos. 86, 112, 42, 226)*, London: Egypt Exploration Fund.

Davies, N. de G., 1943. *The Tomb of Rekh-mi re at Thebes II*, New York: Metropolitan Museum of Art.

Davies, N. & Davies, N. de G., 1923. *The Tombs of Two Officials of Tuthmosis the Fourth*, London: Egypt Exploration Fund.

Davies, N. de G. & Faulkner, R.O., 1947. A Syrian trading venture to Egypt. *JEA*, 33, 40-46.

Day, P.M., Kiriatzi, E., Tsolakidou, A., & Kilikoglou, V., 1999. Group Therapy in Crete: A Comparison Between Analyses by NAA and Thin Section Petrography of Early Minoan Pottery. *JAS*, 26, 1025-1036.

Dever, W.G., 1976. The Beginning of the Middle Bronze Age in Palestine. In F. Cross, W. Lemke, & P. Miller, eds. *Magnalia Dei, The Mighty Acts of God: Essays on the Bible and Archaeology in Memory of G. Ernest Wright*. Garden City, NY: Doubleday, pp. 3-38.

Dever, W.G., 1985. Relations between Syria-Palestine and Egypt in the 'Hyksos' Period. In J. Tubb, ed. *Palestine in the Bronze and Iron Ages: Papers in Honour of Olga Tufnell*. London: Institute of Archaeology, pp. 69-87.

Dever, W.G., 1990. 'Hyksos', Egyptian Destructions, and the End of the Palestinian Middle Bronze Age. *Levant*, 22, 75-81.

Dever, W.G., 1991. Tell el-Dab<sup>c</sup>a and Levantine Middle Bronze Age Chronology: A Rejoinder to Manfred Bietak. *BASOR*, 281, 73-79.

Dever, W.G., 1992. The Chronology of Syria-Palestine in the Second Millennium B.C.: A Review of Current Issues. *BASOR*, 288, 1-25.

Dever, W.G., Lance, H.D., & Wright, G.E., 1970. *Gezer I: preliminary report of the 1964-66 seasons*, Jerusalem: Hebrew Union College Biblical and Archaeological School.

Dever, W.G., Lance, H.D., Bullard, R.G., Cole, D.P., & Seger, J.D., 1974. *Gezer II: report of the 1967-70 seasons in fields I and II*, Jerusalem: Hebrew Union College/Nelson Glueck School of Biblical Archaeology.

van Dijk, J., 2000. The Amarna Period and the Later New Kingdom (c. 1352-1069 BC). In I. Shaw, ed. *The Oxford History of Ancient Egypt*. Oxford: Oxford University Press, pp. 272-313.

Dikaios, P., 1969. *Enkomi: excavations 1948-1958,* Mainz am Rhein: Verlag Phillip von Zabern.

Dothan, M., 1993. Tel Acco. In E. Stern, A. Lewison-Gilboa & J. Aviram, eds. *The New Encyclopaedia of Archaeological Excavations in the Holy Land, Vol. 1.* London: Simon & Schuster, pp. 17-23.

Dothan, T., 1987. The Impact of Egypt on Canaan during the 18th and 19th Dynasties in the Light of the Excavations at Deir el-Balah. In A.F. Rainey, ed. *Egypt, Israel, Sinai: Archaeological and Historical Relationships in the Biblical Period*. Tel Aviv: Tel Aviv University, pp. 121-135.

Doumet-Serhal, C., 2004a. Sidon (Lebanon): Twenty Middle Bronze Age Burials from the 2001 Season of Excavation. *Levant*, 36, 89-154.

Doumet-Serhal, C., 2004b. Excavating Sidon 1998-2003. In C. Doumet-Serhal, ed., in collaboration with A. Rabate and A. Resek. *A Decade of Archaeology and History in the Lebanon.* Beirut: Lebanese British Friends of the National Museum, pp. 102-123.

Doumet-Serhal, C., 2008. The Kingdom of Sidon and its Mediterranean Connections. In C. Doumet-Serhal, ed. in collaboration with A. Rabate and A. Resek, *Networking Patterns of the Bronze and Iron Age Levant. Lebanon and its Mediterranean Connections*. Beirut: AACP, pp. 2-70.

Doumet-Serhal, C. & Griffiths, D., 2003. Middle Bronze Age Jars from Lebanon: A Comparison According to Vessel Capacities. *Archaeology and History in Lebanon*, 17, 38-41.

Dubertret, L., 1945. *Carte géologique au 50.000^e Feuille de Beyrouth*, Beyrouth: Ministére des Travaux Publics, République Libanaise.

Dubertret, L., 1949. *Carte géologique au 50.000^e Feuille de Saida*, Beyrouth: Ministére des Travaux Publics, République Libanaise.

Dubertret, L., 1962. *Liban, Syrie et bordure des pays voisins*, Paris: l'Institut Géographique.

Dubertret, L., 1966. Liban, Syrie, et bordure des pays voisins. *Notes et mémoires sur le Moyen-Orient*, 8, 251-358.

Dubertret, L., 1970. Géologie et Peuplement au Liban. In J. Besancon, ed. *Hannon: revue libanaise de geographie, vol.V*. Beyrouth: Département de Géographie de l'Université Libanaise, pp. 11-20.

Dubertret, L., 1974. Introduction a la Carte Géologique a 1/50,000^e du Liban. *Notes et mémoires sur le Moyen-Orient*, 13, 345-403.

Dubertret, L. & Weztel, R., 1945. *Carte géologique au 50.000^e Feuille de Batroun*, Beyrouth: Ministére des Travaux Publics, République Libanaise.

Dunand, M., 1927. La Cinquième Campagne des Fouilles de Byblos. *Syria*, 8, 93-104.

Dunand, M., 1928. Les égyptiens a Beyrouth. *Syria*, 9, 300-02.

Dunand, M., 1954. *Fouilles de Byblos. Tome II: 1933-1938, Première Partie*, Paris: Maisonneuve.

Dunand, M., 1958. *Fouilles de Byblos. Tome II: 1933-1938, Deuxième Partie*, Paris: Maisonneuve.

Dunand, M., 1964. Rapport Préliminaire sur les fouilles de Byblos en 1963. *Bulletin du Musée de Beyrouth*, 17, 29-35.

Earle, T. & Ericson, J. eds., 1977. *Exchange Systems in Prehistory*, New York: Academic Press.

Edel, E., 1983. Zwei Steinschalen mit ägyptischen Inschriften aus dem Palast von Kamid el-Loz. In R. Hachmann, ed. *Frühe Phönikier im Libanon*. Mainz am Rhein: Verlag Phillip von Zabern, pp. 38-39.

Edel, E., 1997. *Der Vertrag zwischen Ramses II. von Ägypten und Hattušili III. von Hatti*, Berlin: Gebr. Mann Verlag.

Emery, K.O. & Neev, D., 1960. Mediterranean Beaches of Israel. *Bulletin of the Geological Survey of Israel*, 26, 1-24.

Emery, W.B., Smith, H.S. & Millard, A., 1979. *The fortress of Buhen: the archaeological report*, London: Egypt Exploration Society.

Engberg, R., 1939. *The Hyksos Reconsidered*, Chicago: University of Chicago Press.

Engelbach, R., 1915. *Riqqeh and Memphis VI*, London: School of Archaeology in Egypt, University College.

Ericson, J. & Earle, T., 1982. *Contexts for Prehistoric Exchange*, New York: Academic Press.

Eriksson, K.O., 1993. *Red lustrous wheel-made ware*. Studies in Mediterranean Archaeology 103. Jonsered: Paul Åströms Förlag.

Eriksson, K.O., 1995. Egyptian Amphorae from Late Cypriot Contexts in Cyprus. In S. Bourke & J.P. Descoeudres, eds. *Trade, Contact, and the Movement of Peoples in the Eastern Mediterranean, Studies in Honour of J. Basil Hennessy*. Sydney: Meditarch, pp. 199-205.

Eriksson, K.O., 2007. *The creative independence of Late Bronze Age Cyprus: an account of the archaeological importance of white slip ware*, Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Fieller, N.R.J., & Nicholson, P.T., 1991. Grain Size Analysis of Archaeological Pottery: The Use of Statistical Models. In A.P. Middleton & I.C. Freestone, eds. *Recent Developments in Ceramic Petrology*. British Museum Occasional Paper No. 81. London: British Museum Press, pp. 71-110.

Finkelstein, I., 2000. The Philistein Settlements: When, Where and How Many? In E.D. Oren, ed. *The Sea Peoples and Their World: A Reassessment*. Philadelphia: The University Museum, University of Pennsylvania, pp. 159-180.

Finkelstein, I., Ussishkin, D. & Halpern, B. eds, 2000. *Megiddo III: The 1992-1996 Seasons*, Tel Aviv: Emery and Claire Yass Publications in Archaeology, Institute of Archaeology, Tel Aviv University.

Fischer, P.M., 1991. Canaanite Pottery from Hala Sultan Tekke: Traditional Classification and Micro Colour Analysis (MCA). In J.A. Barlow, D. Bolger, & B. Kling, eds. *Cypriot Ceramics: Reading the Prehistoric Record*. University Museum Monograph 74. Philadelphia: University Museum of Archaeology and Anthropology, University of Pennsylvania, pp. 73-80.

Fischer, P.M. & Sadeq, M., 2000. Tell el-‘Ajjul 1999 A Joint Palestinian-Swedish Field Project: First Season Preliminary Report. *Ägypten und Levante*, X, 211-226.

Fischer, P.M. & Sadeq, M., 2002. Tell el-‘Ajjul 2000 Second Season Preliminary Report. *Ägypten und Levante*, XII, 109-153.

Forstner-Müller, I., 2002. Tombs and Burial Customs at Tell el-Dab$^{c}$a in Area A/II at the End of the MB IIA Period (Stratum F). In M. Bietak, ed. *The Middle Bronze Age in the Levant, Proceedings of an International Conference on MB IIA Ceramic Material, Vienna, 24-26th of January 2001, CChEM 3*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 163-184.

Forstner-Müller, I., 2008. *Tell el-Dab$^{c}$a XVI: die Gräber des Areals A/II von Tell el- Dab$^{c}$a*, Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Forstner-Müller, I. & Kopetzky, K., 2006. An Upper Egyptian Import at Sidon. *Archaeology and History in Lebanon*, 24, 60-62.

Forstner-Müller, I., Kopetzky, K. & Doumet-Serhal, C., 2006. Egyptian Pottery of the Late 12th and early 13th Dynasty from Sidon. *Archaeology and History in Lebanon*, 24, 52-59.

Forstner-Müller, I., Müller, W., & Radner, K., 2002. Statuen in Verbannung. Ägyptischer Statuenexport in den Vorderen Orient unter Amenophis III. und IV. *Ägypten und Levante*, XII, 155-166.

Franke, D., 1988a. Zur Chronologie des Mittleren Reiches (12. – 18. Dynastie). Teil I: Die 12. Dynastie. *Orientalia*, 57, 113-138.

Franke, D., 1988b. Zur Chronologie des Mittleren Reiches. Teil II: Die sogenannte 'Zweite Zwischenzeit' Altägyptens. *Orientalia*, 57, 245-274.

Franke, D., 2008. The Late Middle Kingdom (Thirteenth to Seventeenth Dynasties): The Chronological Framework. *Journal of Egyptian History*, 1(2), 267-287.

Franklin, U. M., & Vitali, V., 1985. The environmental stability of ancient ceramics. *Archaeometry*, 27, 3–15.

Freestone, I.C., 1995. Ceramic Petrography. *AJA*, 99, 111-115.

Freestone, I.C., Johns, C. & Potter, T. eds., 1982. *Current research in ceramics: thin-section studies*, London: British Museum

Freestone, I.C., Meeks, N.D., & Middleton, A.P., 1985. Retention of Phosphate in Buried Ceramics: An Electron Microbeam Approach. *Archaeometry*, 27(2), 161-177.

French, E.B., 1990. Archaeology in Greece 1989-1990. *Archaeological Reports for 1989-1990*, 36, 3-82.

Fuscaldo, P., 2000. *Tell el-Dab$^{c}$a X. The Palace District of Avaris. The Pottery of the Hyksos Period and the New Kingdom (Areas H/III and H/VI). Part I: Locus 66*, Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Fuscaldo, P., 2001. Preliminary report on the 18$^{th}$ Dynasty pottery from ʿEzbet Helmi, Area H/III-t-u/17 (the bathroom). *Ägypten und Levante*, XI, 149-166.

Gale, N. ed., 1991. *Bronze Age Trade in the Mediterranean*, Jonsered: Paul Åströms Förlag.

Gardiner, A., Peet, T. & Černý, J., 1955. *The Inscriptions of Sinai II*, London: Egypt Exploration Society.

Garstang, J., 1901. *El Arábah: A cemetery of the Middle Kingdom. Survey of the Old Kingdom temenos. Graffiti from the temple of Sety*, London: British School of Archaeology in Egypt.

Gasche, H., Armstrong, J.A., Cole, S.W., & Gurzadyan, V.G., 1998. *Dating the Fall of Babylon. A Reappraisal of Second-Millennium Chronology*, Ghent: University of Ghent.

Gass, I.G., MacLeod, C.J., Murton, B.J., Panayiotou, A., Simonian, K.O., & Xenophontos, C., 1994. *The Geology of the Southern Troodos Transform Fault Zone*. Cyprus Geological Survey Department Memoir No. 9. Nicosia: Geological Survey Department.

Gerstenblith, P., 1983. *The Levant at the Beginning of the Middle Bronze Age*, Philadelphia: American Schools of Oriental Research.

Giddy, L.L., 1999. *Kom Rabi'a: the New Kingdom and Post-New Kingdom objects*, London: Egypt Exploration Society.

Giddy, L.L., & Jeffreys, D.G., 1991. Memphis, 1990. *JEA*, 77, 1-6.

Giddy, L.L. & Jeffreys, D.G., 1993. Memphis, 1991. *JEA*, 79, 11-16.

Giddy, L.L., Jeffreys, D.G., & Bourriau, J., 1996. Memphis, 1995. *JEA*, 82, 1-3.

Giddy, L.L., Jeffreys, D.G., & Malek, J., 1990. Memphis, 1989. *JEA*, 76, 1-15.

Giorgini, M.S., 1971. *Soleb II, Les Nécropoles*, Firenze: Sansoni.

Giveon, R., 1987. The Impact of Egypt on Canaan in the Middle Bronze Age. In A.F. Rainey, ed. *Egypt, Israel, Sinai: Archaeological and Historical Relationships in the Biblical Period*. Tel Aviv: Tel Aviv University, pp. 23-40

Gliozzo, E., Fortina, C., & Memmi Turbanti, I., 2005. Cooking and Painted Ware from San Giusto (Lucera, Foggia): The Production Cycle, from the Supply of Raw Materials to the Commercialization of Products. *Archaeometry*, 47(1), 13-29.

Goedicke, H., 1991. Egyptian Military Actions in "Asia" in the Middle Kingdom. *Revue d'Égyptologie*, 42, 89-94.

Goldberg, P., Gould, B., Killebrew, A. & Yellin, J., 1986. Comparison of neutron activation and thin-section analyses on Late Bronze Age ceramics from Deir el-Balah. In J.S. Olin & M.J. Blackman, eds. *Proceedings of the 24th International Archaeometry Symposium*. Washington, D.C., pp. 341-351.

Goldsmith, V. & Golik, A., 1980. Sediment Transport Model of the Southeastern Mediterranean Coast. *Marine Geology,* 37, 147-175.

Gophna, R. & Portugali, J., 1988. Settlement and Demographic Processes in Israel's Coastal Plain from the Chalcolithic to the Middle Bronze Age. *BASOR*, 296, 11-28.

Goren, Y., 2003. Book Review: McGovern, P.E. 2000. The Foreign Relations of the "Hyksos", BAR Int.Ser. 888, Oxford 2000. *Bibliotheca Orientalis*, 60(1-2), 105-110.

Goren, Y. & Cohen-Weinberger, A., 2002. Petrographic Analyses of Selected Wares. In A. Kempinski, ed. *Tel Kabri: the 1986-1993 excavation seasons*. Tel Aviv: Emery and

Claire Yass Publications in Archaeology, Institute of Archaeology, Tel Aviv University, pp. 435-442.

Goren, Y., Finkelstein, I. & Na'aman, N., 2003. The Expansion of the Kingdom of Amurru According to the Petrographic Investigation of the Amarna Tablets. *BASOR*, 329, 1-11.

Goren, Y., Finkelstein, I. & Na'aman, N., 2004. *Inscribed in Clay, Provenance Study of the Amarna Tablets*, Tel Aviv: Emery and Claire Yass Publications in Archaeology.

Grace, V.R., 1956. The Canaanite Jars. In S.S. Weinberg, ed. *The Aegean and the Near East: Studies Presented to Hetty Goldman on the Occasion of Her Seventy-fifth Birthday*. Locust Valley, NY: J.J. Augustin, pp. 80-109.

Grace, V.R., 1961. *Amphoras and the Ancient Wine Trade*, Princeton: American School of Classical Studies at Athens.

Grajetzki, W., 2006. T*he Middle Kingdom of Ancient Egypt*, London: Duckworth.

Gribble, C.D. & Hall, A.J., 1992. *Optical Mineralogy: Principles and Practice*, Boca Raton, FL: CRC Press.

Griffiths, D., 2003. Petrographic Analysis of Middle Bronze Age Burial Jars from Sidon. *Archaeology and History in Lebanon*, 17, 17-21.

Griffiths, D. & Ownby, M.F., 2006. Assessing the Occurrence of Egyptian Marl C Ceramics in Middle Bronze Age Sidon. *Archaeology and History in Lebanon*, 24, 63-77.

Guasch-Jané, M.R., 2008. *Wine In Ancient Egypt: A Cultural and analytical study*, Oxford: Archaeopress.

Guerrer, A. & Sanlaville, P., 1970. Sur les hautes niveaux marins quaternaires du Liban. In J. Besancon, ed. *Hannon: revue libanaise de geographie, vol.V*. Beyrouth: Département de Géographie de l'Université Libanaise, pp. 21-26.

Guigues, P.E., 1938. Lebeaʿ, Kafer Garra, Qrayé necropolis de la region sidonienne. *Bulletin du Musée de Beyrouth*, 2, 35-76.

Gunneweg, J., Perlman, I., & Asaro, F., 1987. A Canaanite Jar from Enkomi. *IEJ*, 37(2-3), 168-172.

Gvirtzman, G., Netser, M., & Katsav, E., 1998. Last-Glacial to Holocene kurkar ridges, hamra soils, and dune fields in the coastal belt of central Israel. *Israel Journal of Earth Sciences*, 47, 29-46.

Hachmann, R., 1980. *Bericht über die Ergebnisse der Ausgrabungen in Kāmid el-Lōz in den Jahren 1968 bis 1970*, Bonn: Habelt.

Hachmann, R. ed., 1983. *Frühe Phönikier im Libanon*, Mainz am Rhein: Verlag Phillip von Zabern.

Hadjicosti, M., 1988. Appendix IV, Part 1: 'Canaanite' Jars from Maa-Palaeokastro. In V. Karageorghis & M. Demas, eds, *Excavations at Maa-Palaeokastro 1979-1986*. Nicosia: Department of Antiquities, Cyprus, pp. 340-363.

Hadjisavvas, S., 1986. Alassa: A New Late Cypriote Site. *Report of the Department of Antiquities of Cyprus*, 44-59.

Haldane, C., 1990. Shipwrecked Plant Remains. *Biblical Archaeologist*, 53(1), 55-60.

Hamada, A. & Farid, S., 1947. Excavations at Kom el-Hisn Season 1945. *ASAE*, 46, 195-235.

Harbottle, G., 1970. Neutron activation analysis of sherds from Knossos and Mycenae. *Archaeometry*, 12, 23-34.

Harbottle, G., 1982. Provenience Studies Using Neutron Activation Analysis: The Role of Standardization. In J.S. Olin & A.D. Franklin, eds. *Archaeological Ceramics*. Washington D.C.: Smithsonian Institution Press, pp. 67-77.

Hart, F.A., Storey, J.M.V., Adams, S.J., Symonds, R.P., & Walsh, J.N., 1987. An Analytical Study, Using Inductively Coupled Plasma (ICP) Spectrometry, of Samian and Colour-Coated Wares from the Roman Town at Colchester together with Related Continental Samian Wares. *JAS*, 14, 577-598.

Hartung, U.v., 2001. *Umm el-Qaab II: Imporkeramik aus dem Friedhof U in Abydos (Umm el-Qaab) und die Beziehungen Ägyptens zu Vorderasien im 4. Jahrtausend v. Chr*, Mainz am Rhein: Verlag Phillip von Zabern.

Hasel, M., 1998. *Domination and Resistance. Egyptian Military Activity in the Southern Levant, ca. 1300-1185 B.C.*, Leiden: Brill.

Hawkins, J. ed., 1977. *Trade in the Ancient Near East*, London: British School of Archaeology in Iraq.

Haynes, J.R., 1981. *Foraminifera*, London: Macmillan Publishers Ltd.

Hein, A., Mommsen, H. & Maran, J., 1999. Element Concentration Distributions and Most Discriminating Elements for Provenancing by Neutron Activation Analyses of Ceramics from Bronze Age Sites in Greece. *JAS*, 26, 1053-1058.

Hein, A., Tsolakidou, A., Iliopoulos, I., Mommsen, H., Buxeda i Garrigós, J., Montana, G., & Kilikoglou, V., 2002. Standardisation of elemental analytical techniques applied to provenance studies of archaeological ceramics: an inter laboratory calibration study. *Analyst*, 127, 542-553.

Hein, I., 2004. Palestinian Imports at Karnak North. *Bulletin de Liaison due Groupe International d'Étude de la Céramique Égyptienne*, XXII, 49-53.

Hein, I. ed., 2007. *The lustrous wares of Late Bronze Age Cyprus and the Eastern Mediterranean: papers of a conference, Vienna 5th-6th of November 2004*, Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Hein, I. & Jánosi, P., 2004. *Tell el-Dab[c]a. XI. Areal A/V siedlungsrelikte der späten 2: Zwischenzeit*, Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Heinz, M., 1992. *Tell Atchana/Alalakh: die Schichten VII-XVII*, Neukirchen-Vluyn: Neukirchener Verlag.

Helck, W., 1976. Ägyptische Statuen im Ausland - Ein Chronologisches Problem. *Ugarit Forschungen*, 8, 101-115.

Helck, W., 1983. *Historisch-biographische Texte der 2. Zwischenzeit und neue Texte der 18. Dynastie*, Wiesbaden: Otto Harrassowitz.

Heltzer, M., 1978. *Goods, Prices, and the Organization of Trade in Ugarit*, Wiesbaden: Dr. Ludwig Reichert Verlag.

Hennessy, J.B. & du Plat Taylor, J., 1967. The pottery. In G. F. Bass, ed. *Cape Gelidonya: A Bronze Age Shipwreck.* Transactions of the American Philosophical Society 57 (part 8). Philadelphia: The American Philosophical Society, pp. 122-125.

Heuck, S., 1981. Kalavasos-Ayios Dhimitrios 1979. A Preliminary Ceramic Analysis. *Report of the Department of Antiquities of Cyprus*, 64-80.

Higginbotham, C., 2000. *Egyptianization and Elite Emulation in Ramesside Palestine: Governance and Accommodation on the Imperial Periphery*, Boston: Brill.

Hirth, K., 1978. Interregional Trade and the Formation of Prehistoric Gateway Communities. *American Antiquity*, 43(1), 35-45.

Hodges, H.W.M., 1962. Thin sections of prehistoric pottery: an empirical study. *Bulletin of the Institute of Archaeology*, 3, 58-68.

Hoffmeier, J.K., 1989. Reconsidering Egypt's Part in the Termination of the Middle Bronze Age in Palestine. *Levant*, 21, 181-193.

Hoffmeier, J.K., 1990. Some Thoughts on William G. Dever's "'Hyksos', Egyptian Destruction, and the End of the Palestinian Middle Bronze Age." *Levant*, 22, 83-89.

Hoffmeier, J.K., 1991. James Weinstein's "Egypt and the Middle Bronze IIC/Late Bronze IA Transition': A Rejoinder. *Levant*, 23, 117-124.

Hoffmeier, J.K., 2004. Aspects of Egyptian Foreign Policy in the 18$^{th}$ Dynasty in Western Asia and Nubia. In G. Knoppers & A. Hirsch, eds. *Egypt, Israel, and the Ancient Mediterranean World: Studies in Honor of Donald B. Redford*. Leiden: Brill, pp. 121-141.

Holladay, J.J., 1982. *Cities of the Delta; Tell el-Maskhuta, preliminary report on the Wadi Tumilat Project, 1978-1979. Part 3*, Malibu: Undena.

Holladay, J.J., 1997. The Eastern Nile Delta During the Hyksos and Pre-Hyksos Periods: Toward a Systemic/Socioeconomic Understanding. In E.D. Oren, ed. *The Hyksos: New Historical and Archaeological Perspectives*. Philadelphia: University of Pennsylvania Museum, pp. 183-252.

Holladay, J.J., 2001a. Pithom. In D.B. Redford, ed. *Oxford Encyclopedia of Ancient Egypt, Vol. 3*. Oxford: Oxford University Press, pp. 50-53.

Holladay, J.J., 2001b. Tell el-Yahudiya. In D.B. Redford, ed. *Oxford Encyclopedia of Ancient Egypt, Vol. 3*. Oxford: Oxford University Press, pp. 527-529.

Holmes, L.J., Robinson, V.J., Makinson, P.R. & Livens, F.R., 1995. Multi-element determination in complex matrices by inductively coupled plasma-mass spectrometry (ICP-MS). *The Science of the Total Environment*, 173/174, 345-350.

Holthoer, R., 1977. *New Kingdom Pharaonic Sites. The Pottery*, Lund: The Scandinavian Joint Expedition to Sudanese Nubia.

Hope, C., 1978. *Malkata and the Birket Habu 1971-1974. Jar Sealings and Amphorae of the 18$^{th}$ Dynasty: A Technological Study*. Egyptology Today, No. 2, Vol. V. Warminster: Aris & Phillips Ltd.

Hope, C., 1989. Amphorae of the New Kingdom. In C. Hope, ed. *Pottery of the New Kingdom; Three Studies*. Victoria College Archaeology Research Unit Occasional Paper 2. Burwood, Victoria: Victoria College, pp. 87-110.

Hornung, E., Krauss, R. & Warburton, D. eds., 2006. *Ancient Egyptian Chronology*, Leiden: Brill.

Hughes, M.J., 1981. *Scientific Studies in Ancient Ceramics*. British Museum Occasional Paper No. 19. London: British Museum Press.

Hughes, M.J., Cowell, M., & Hook, D., 1991. *Neutron Activation and Plasma Emission Spectrometric Analysis in Archaeology*. British Museum Occasional Paper 82. London: British Museum.

Hulin, L., 2002a. Chapter 8: Bronze Age Plain Pottery: Egyptian, Canaanite and Cypriot. In D. White, ed. *Marsa Matruh: the University of Pennsylvania Museum of Archaeology and Anthropology's excavations on Bates's Island, Marsa Matruh, Egypt 1985-1989*. Philadelphia: Institute for Aegean Prehistory Academic Press, pp. 17-45.

Hulin, L., 2002b. Book Review: The Foreign Relations of the "Hyksos". A neutron activation study of Middle Bronze Age Pottery from the Eastern Mediterranean. P.E. McGovern, with a contribution by T. Bagh, BAR InternationalSeries 888, 2000. *Discusssions in Egyptology*, 53, 115-122.

Hunger, H. & Pruzsinszky, R. eds., 2004. *Mesopotamian Dark Age revisited: proceedings of an International Conference of SCIEM 2000 (Vienna, 8th-9th November 2002)*, Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Iamoni, M., 2008. The MB II and Late Bronze Age Simple Ware from Tell Mishrifeh/Qatna. In M. Bietak & E. Czerny, eds. *The Bronze Age in the Lebanon. Studies on the Archaeology and Chronology of Lebanon, Syria, and Egypt*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 93-114.

Ilaiwi, M., 1985. *Soil Map of Arab Countries, Soil Map of Syria and Lebanon*, Damascus: The Arab Center for the Studies of Arid Zones and Dry Lands, Soil Sciences Division.

Jarvis, K.E., Gray, A.L., & Houk, R.S., 1992. *Handbook of Inductively Coupled Plasma Mass Spectrometry*, Glasgow: Blackie.

Jeffreys, D.G., 1985. *The survey of Memphis. Pt. 1, The archaeological report*, London: Egypt Exploration Society.

Jeffreys, D.G., 2006. *Kom Rabia: the new kingdom settlement (Levels II-V). Survey of Memphis V*, London: Egypt Exploration Society.

Jeffreys, D.G., & Giddy, L.L., 1989. Memphis, 1988. *JEA*, 75, 1-12.

Jeffreys, D.G. & Giddy, L.L., 1993. Looking for Memphis, *Egyptian Archaeology*, 1, 5-8.

Jeffreys, D.G., & Malek, J., 1988. Memphis, 1986, 1987. *JEA*, 74, 15-29.

Jeffreys, D.G., Bourriau, J. & Johnson, W.R., 2000. Memphis, 1999. *JEA*, 86, 5-12.

Jefferys, D.G., Malek, J. & Smith, H.S., 1986. Memphis, 1984. *JEA*, 72, 1-14.

Jefferys, D.G., Malek, J. & Smith, H.S., 1987. Memphis, 1985. *JEA*, 73, 11-20.

Jidejian, N., 1971. *Byblos Through the Ages 2nd Ed.*, Beirut: Dar el-Machreq Publishers.

Jones, R.E., 1986. *Greek and Cypriot Pottery: a review of scientific studies*. Fitch Laboratory Occasional Paper 1. Athens: British School at Athens.

Jones, R.E., & Vaughn, S.J., 1988. Appendix IV, Part 2: A Study of Some 'Canaanite' Jar Fragments from Maa-Palaeokastro by Petrographic and Chemical Analysis. In V. Karageorghis & M. Demas, eds. *Excavations at Maa-Palaeokastro 1979-1986*. Nicosia: Department of Antiquities, Cyprus, pp. 386-398.

Kamrin, J., 2009. The Aamu of Shu in the Tomb of Khnumhotep II at Beni Hassan. *Journal of Ancient Egyptian Interconnections*, 1(3), 22-36.

Kaplan, J., 1955. A Cemetery of the Bronze Age Discovered near Tel Aviv Harbour. *ʽAtiqot*, 1, 1-12.

Kaplan, J. & Ritter-Kaplan, H., 1993. Jaffa. In E. Stern, A. Lewison-Gilboa & J. Aviram, eds. *The New Encyclopaedia of Archaeological Excavations in the Holy Land, Vol. 2.* London: Simon & Schuster, pp. 655-659.

Kaplan, M., 1980. *The Origin and Distribution of Tell el-Yahudiyeh Ware,* Göteborg: Paul Åströms Förlag.

Kaplan, M., Harbottle, G. & Sayre, E., 1982. Multi-Disciplinary Analysis of Tell el Yahudiyeh Ware. *Archaeometry*, 24, 127-142.

Karageorghis, V. ed., 1986. *Acts of the International Archaeology Symposium "Cyprus between the Orient and the Occident"*, Nicosia: Department of Antiquities, Cyprus.

Karageorghis, V. ed., 2001. *The White slip ware of late Bronze Age Cyprus: proceedings of an International Conference organized by the Anastasios G. Leventis Foundation, Nicosia in honour of Malcolm Wiener, Nicosia 29th-30th October 1998,* Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Karageorghis, V., & Demas, M., 1984. *Pyla-Kokkinokremos: A Late 13th Century B.C. Fortified Settlement in Cyprus*, Nicosia: Department of Antiquities, Cyprus.

Karageorghis, V., & Demas, M., 1985. *Excavations at Kition. Vol.5, The pre-phoenician levels (Areas I and II),* Nicosia: Department of Antiquities, Cyprus.

Kempinski, A., 1974. Tell el-'Ajjul – Beth Aglayim or Sharuhen? *IEJ,* 24 (3-4), 145-152.

Kempinski, A., 2002. *Tel Kabri: the 1986-1993 excavation seasons,* Tel Aviv: Emery and Claire Yass Publications in Archaeology, Institute of Archaeology, Tel Aviv University.

Kenyon, K., 1960. *Excavations at Jericho. Vol. I: The Tombs excavated in 1952-1954*, London: Harrison.

Kenyon, K., 1979. *Archaeology in the Holy Land, 4th Ed*., London: Ernest Benn Limited.

Kilian, K., 1988a. Ausgrabungen in Tiryns, 1932/1983, Bericht zu den Grabungen. *Archäologischer Anzeiger*, 105-51.

Kirby, C., Orel, S. & Smith, S., 1998. Preliminary Report on the Survey of Kom el-Hisn, 1996. *JEA*, 84, 23-43.

Kitchen, K., 1987. The Basics of Egyptian Chronology in Relation to the Bronze Age. In P. Åström, ed. *High, Middle, or Low? Acts of an International Colloquium on Absolute Chronology Held at the University of Gothenburg 20th – 22nd of August 1987*. Göteborg: P. Åströms Förlag, pp. 37-55.

Kitchen, K., 1999. *Ramesside Inscriptions. Translated and Annotated: Notes and Comments 2: Ramesses II, Royal Inscriptions,* Oxford: Blackwell.

Kitchen, K., 2000. Regnal and Genealogical Data of Ancient Egypt (Absolute Chrnology I). The Historical Chronology of Ancient Egypt, a Current Assessment. In M. Bietak, ed. *The Synchronisation of Civilisations in the Eastern Mediterranean in the Second Millennium B.C., Proceedings of an International Symposium at Schloß Haindorf, 15th – 17th of November 1996 and at the Austrian Academy, Vienna, 11th – 12th of May 1998*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 39-52.

Kitchen, K., 2006. The Strengths and Weaknesses of Egyptian Chronology – A reconsideration. *Ägypten und Levante*, XVI, 293-308.

Klein, M., Jesse, F., Kasper, H.U., & Gölden, A., 2004. Chemical Characterization of Ancient Pottery from Sudan by X-ray Fluorescence Spectrometry (XRF), Electron Microprobe Analyses (EMPA), and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). *Archaeometry*, 46(3), 339–356.

Klengel, H., 1992. *Syria, 3000 to 300 B.C. a handbook of political history,* Berlin: Akademie Verlag.

Klengel, H., 1995. Tunip und andere Probleme der historischen Geographie Mittelsyriens. In K. van Lerberghe & A. Schoors, eds. *Immigration and Emigration within the Ancient Near East*. Leuven: Uitgeverij Peeters en Departement Oriëntalistiek, pp. 125-134.

Knapp, A., 1993. Thalassocracies in Bronze Age eastern Mediterranean trade: making and breaking a myth. *World Archaeology*, 24(3), 332-347.

Kochavi, M., 1975. The First Two Seasons of Excavations at Aphek-Antipatris. *Tel Aviv*, 2, 17-42.

Kochavi, M. & Yadin, E., 2002. Typological Analysis of the MB IIA Pottery from Aphek according to its Stratigraphic Provenance. In M. Bietak, ed. *The Middle Bronze Age in the Levant, Proceedings of an International Conference on MB IIA Ceramic Material, Vienna, 24-26th of January 2001, CChEM 3*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 189-225.

Koenig, Y., 1979. *Catalogue des etiquettes de jarres hiératiques de Deir el-Médineh: Nos. 6000-6241,* Le Caire: Institut Français d'Archéologie Orientale.

Kohl, P. L., 1987. The Use and Abuse of World Systems Theory: The Case of the Pristine West Asian State. In M. Schiffer, ed. *Advances in Archaeological Method and Theory, Vol. 11*. New York: Academic Press, pp. 1-35.

Kohl, P. L., 1996. The Ancient Economy, Transferable Technologies and the Bronze Age World-system: a View from the Northeastern Frontier of the Ancient Near East. In R.W. Preucel and I. Hodder, eds. *Contemporary Archaeology in Theory*. Oxford: Blackwell Publishers, pp. 143-164.

Kopetzky, K., 2004. Statistische Auswertung der Siedlungskeramik vom Planquadrat p/19. In I. Hein & P. Jánosi, eds. *Tell el-Dab^c^a. XI, Areal A/V siedlungsrelikte der späten 2:*

*Zwischenzeit*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 237-336.

Kopetzky, K., 2007/2008. Pottery from Tell Arqa Found in Egypt and Its Chronological Contexts. *Archaeology and History in Lebanon*, 26-27, 17-58.

van Koppen, F., 2007. Syrian Trade Routes of the Mari Age and MB II Hazor. In M. Bietak & E. Czerny, eds. *The Synchronization of Civilizations in the Eastern Mediterranean in the Second Millennium B.C. II, Vol. III*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 367-374.

Krauss, R., 1985. *Sothis und Monddaten: Studien zur astronomischen und technischen Chronologie Altägyptens*, Hildesheim: Gerstenberg.

Kuleff, I. & Djingova, R., 1996. Provenance Study of Pottery: Choice of Elements to be Determined. *Revue d'Archéométrie*, 20, 57-67.

Kuhrt, A., 1995. *The ancient Near East: c. 3000-330 B.C.*, New York: Routledge.

Leahy, M. A., 1978. *Excavations at Malkata and the Birket Habu 1971-1974: The Inscriptions*, Warminster: Aris and Phillips.

Lecuyot, G., 1997. A propos de quelques bouchons de jarres provenant du Ramesseum. *Memnonia*, 8, 107-118.

Leese, M.N., 1983. The statistical treatment of grainsize data from pottery. In A. Aspinall & S.E. Warren, eds. *Proceedings of the 22nd Archaeometry Symposium*. Bradford: Schools of Physics and Archaeological Sciences, University of Bradford, pp. 47-55.

Leonard, A. Jr., 1995. "Canaanite jars" and the Late Bronze Age Aegeo-Levantine wine trade. In P.E. McGovern, S.J. Fleming, & S.H. Katz, eds. *The Origins and Ancient History of Wine*. Luxembourg: Gordon and Breach, pp. 233-254.

Lesko, L.H., 1995. Egyptian Wine Production During the New Kingdom. In P.E. McGovern, S.J. Fleming, & S.H. Katz,eds. *The Origins and Ancient History of Wine*. Luxembourg: Gordon and Breach, pp. 215-230.

Lichtheim, M., 1973. *Ancient Egyptian Literature, Volume 1: The Old and Middle Kingdoms*, Berkeley: University of California Press.

Lilyquist, C., 1993. Granulation and Glass: Chronological and Stylistic Investigations at Selected Sites, ca. 2500- 1400 B. C. E. *BASOR*, 290/291, 29-94.

Linné, S., 1925. *The Techniques of South American Ceramics*. Handlingar, Fjärde Följden, Band 29, No. 5. Göteborg: Kungl. Vetenskapsoch Vitterhets-Samhälles,

Linné, S., 1957. Technical Secrets of American Indians. *Journal of the Royal Anthropological Institute*, 87(2), 149-164.

Liverani, M., 1990. *Prestige and Interest. International Relations in the Near East ca. 1600-1100 B.C.*, Padova: Sargon SRL.

Liverani, M., 2003. The Influence of Political Institutions on Trade in the Ancient Near East (Late Bronze Age to Early Iron Age). In C. Zaccagnini, ed. *Mercanti e Politica nel Mondo Antico. Saggi di Storia Antica*. Rome: L'Erma di Bretschneider, pp. 119-137.

Loud, G., 1948. *Megiddo II: seasons of 1935-39*, Chicago: University of Chicago Press.

Macalister, R.A.S., 1912. *The excavations of Gezer, 1902-1905 and 1907-1909, 3 Vols*, London: Published for the Committee of the Palestine Exploration Fund by J. Murray.

Magrill, P. & Middleton, A., 2004. Late Bronze Age Pottery Technology: Cave 4034 Revisited. In D. Ussishkin, ed. *The Renewed Archaeological Excavations at Lachish (1973-1994), Vol. V*. Tel Aviv: Emery and Claire Yass Publications in Archaeology, Institute of Archaeology, Tel Aviv University, pp. 2514-2549.

Maguire, L.C., 1990. *The Circulation of Cypriot Pottery in the Middle Bronze Age*. Unpublished Ph.D. dissertation, University of Edinburgh.

Malamat, A., 1971. Syro-Palestinian Destinations in a Mari Tin Inventory. *IEJ*, 21, 31-38.

Malek, J. & Quirke, S., 1992. Memphis, 1991: Epigraphy. *JEA*, 78, 13-18.

Maniatis, Y., Jones, R.E., Whitbread, I.K., Kostikas, A., Simopoulos, A., Karakalos, C. & Willam, C.K., 1984. Punic amphorae found at Corinth, Greece: an investigation of their origin and technology. *Journal of Field Archaeology*, 11, 205-222.

Manning, S. & Hulin, L., 2005. Maritime Commerce and Geographies of Mobility in the Late Bronze Age of the Eastern Mediterranean: Problematizations. In E. Blake & A. Knapp, eds. T*he Archaeology of Mediterranean Prehistory*. Oxford: Blackwells, pp. 270-302.

Marcus, E.S., 1995. A Petrographic Analysis of Storage Jars from Tel Nami, Israel: Ceramic Production and Trade Networks of the Middle Bronze IIA Period (ca. 2000-1750 BC). In P.B. Vandiver, J.R. Druzik, L.G. Madrid, I.C. Freestone, & G.S. Wheeler, eds. *Materials in Art and Archaeology IV*, Materials Research Society Symposium Proceedings 352. Pittsburgh: Materials Research Society, pp. 597-603.

Marcus, E.S., 2007. Amenemhat II and the Sea: Maritime Aspects of the Mit Rahina (Memphis) Inscription. *Ägypten und Levante*, XVII, 137-190.

Marcus, E.S., Porath, E., Schiestl, R., Seiler, A., & Paley, S.M., 2008. The Middle Kingdom Egyptian Pottery from Middle Bronze Age IIa Tel Ifshar. *Ägypten und Levante*, XVIII, 203-219.

Marinatos, S., 1976. *Excavations at Thera VII: (1973 season)*, Athens: Hēen Athēnais Archaiologikē Hetaireia.

Martin, G.T., 1989. *The Memphite Tomb of Horemheb, Commander-in-Chief of Tut'ankhamun*, London: Egypt Exploration Society.

Martin, G.T., 1998. The Toponym Retjenu on a Scarab from Tell el-Dab$^{c}$a. *Ägypten und Levante*, VIII, 109-112.

Martin, G.T., 1999. Alalakh 194: an ancient seal-impression re-interpreted. In A. Leahy & J. Tait, eds. *Studies on Ancient Egypt in Honour of H.S. Smith*. London: Egypt Exploration Society, pp. 201-207.

Martin, M.A.S., 2004. Egyptian and Egyptianized Pottery in Late Bronze Age Canaan. *Ägypten und Levante*, XIV, 265-284.

Martin, M.A.S., 2007. A Collection of Egyptian and Egyptian-style Pottery at Beth-Shean. In M. Bietak & E. Czerny,eds. *The Synchronisation of Civilisations in the Eastern Mediterranean in the Second Millennium B.C. III. Proceedings of the SCIEM 2000 – 2nd EuroConference, Vienna, 28th of May – 1st of June 2003*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 375-388.

Martin, M.A.S., 2008. Egyptians at Ashkelon? An Assemblage of Egyptian and Egyptian-Style Pottery. *Ägypten und Levante*, XVIII, 245-274.

Martin, M.A.S., 2009. Egyptian-type Eighteenth Dynasty Pots at Megiddo. *Ägypten und Levante*, XIX, 211-218.

Martin, M.A.S. & Ben-Dov, R., 2007. Egyptian and Egyptian-style Pottery at Tell Dan. *Ägypten und Levante*, XVII, 191-204.

Master, D., 2003. Trade and politics: Ashkelon's Balancing Act in the Seventh Century B.C.E. *BASOR*, 330, 47-64.

Matthew, A.J., Woods, A.J. & Oliver, C., 1991. Spots Before the Eyes: New Comparison Charts for Visual Percentage Estimation in Archaeological Material. In A.P. Middleton & I.C. Freestone, eds. *Recent Developments in Ceramic Petrology*. British Museum Occasional Paper No. 81. London: British Museum Press, pp. 211-264.

Matthiae, P., 1980. *Ebla: An Empire Rediscovered*, London: Hodder and Stoughton.

Matthiae, P., 1997. Ebla and Syria in the Middle Bronze Age. In E.D. Oren, ed. *The Hyksos: New Historical and Archaeological Perspectives*. Philadelphia: University of Pennsylvania Museum, pp. 379-414.

Mazar, A., 1968. The Middle Bronze Age in Palestine. *IEJ*, 18(2), 65-97.

Mazar, A., 1988. A Note on Canaanite Jars from Enkomi. *IEJ*, 38(4), 224-226.

McGovern, P.E., 1997. Wine of Egypt's Golden Age. *JEA*, 83, 69-108.

McGovern, P.E., 2000. T*he Foreign Relations of the "Hyksos". A neutron activation study of Middle Bronze Age pottery from the Eastern Mediterranean*, Oxford: Archaeopress.

McGovern, P.E., 2001. The Origins of the Tomb U-j Syro-Palestinian Type Jars as Determined by Neutron Activation Analysis. In U.v. Hartung, ed. *Umm el-Qaab II: Imporkeramik aus dem Friedhof U in Abydos (Umm el-Qaab) und die Beziehungen Ägyptens zu Vorderasien im 4. Jahrtausend v. Chr*. Mainz am Rhein: Verlag Phillip von Zabern, pp. 407-416.

McGovern, P.E. & Harbottle, G., 1997. Hyksos" Trade Connections between Tell el-Dab[c]a (Avaris) and the Levant: A Neutron Activation Study of the Canaanite Jar. In E.D. Oren, ed. *The Hyksos: New Historical and Archaeological Perspectives*. Philadelphia: University of Pennsylvania Museum, pp. 141-157.

McNicoll, A.W., Edwards, P.C., Hanbury-Tenison, J., Hennessy, J.B., Potts, T.F., Smith, R.H., Walmsley, A., & Watson, P., 1992. *Pella in Jordan. 2, The second interim report of the joint University of Sydney and College of Wooster excavations at Pella 1982-1985,* Sydney: Meditarch.

Mellink, M.J., 1993. New Perspectives and Initiatives in the Hyksos Period. *Ägypten und Levante*, V, 85-89.

Merrillees, R., 1974. *Trade and Transcendence in the Bronze Age Levant*, Göteborg: Studies in Mediterranean Archaeology.

Middleton, A.P. & Freestone, I.C. eds., 1991. *Recent Developments in Ceramic Petrology*. British Museum Occasional Paper No. 81. London: British Museum Press.

Middleton, A.P., Freestone, I.C. & Leese, M.N., 1985. Textural analysis of ceramic thin sections: evaluation of grain sampling procedures. *Archaeometry*, 27, 64-74.

Middleton, A.P., Leese, M.N., & Cowell, M.R., 1991. Computer-Assisted Approaches to the Grouping of Ceramic Fabrics. In A.P. Middleton & I.C. Freestone, eds. *Recent Developments in Ceramic Petrology*. British Museum Occasional Paper No. 81. London: British Museum Press, pp. 265-267.

Mills, J.S. & White, R., 1989. The identity of the resins from the Late Bronze Age shipwreck at Ulu Burun (Kaş). *Archaeometry,* 31(1), 37-44.

Mlinar, C., 2004. The Scarab Workshops of Tell el-Dab[c]a. In M. Bietak & E. Czerny, eds. *Scarabs of the Second Millennium BC from Egypt, Nubia, Crete, and the Levant: Chronological and Historical Implications. Papers of a Symposium, Vienna, 10th – 13th of January 2002*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 107-140.

Mommsen, H., Kreuser, A., & Weber, J., 1988. A Method for Grouping Pottery by Chemical Composition. *Archaeometry*, 30(1), 47-57.

Monroe, C., 2005. Chapter 11: Money and Trade. In D. Snell, ed. *A Companion to the Ancient Near East*. Oxford: Blackwell, pp. 155-168.

Montet, P., 1928. *Byblos et l'Egypte: quatre campagnes de fouilles à Gebeil, 1921-1922-1923-1924*, Paris: Paul Geuthner.

Montet, P., 1937. *Les Reliques de l'Art Syrien dans l'Egypte du Nouvel Empire*, Paris: Société d'Édition, Les Belles Lettres.

Montet, P., 1954. Notes et Documents pour Servir à l'Histoire des Relations entre l'Ancienne Égypte et la Syrie. *Kêmi*, 13, 63-76.

Moran, W.L., 1992. *The Amarna Letters*, Baltimore: Johns Hopkins University Press.

de Morgan, J., 1895. *Fouilles à Dahchour*, Vienne: A. Holzhausen.

Muhly, J.D., 1986. The Role of Cyprus in the Economy of the Eastern Mediterranean during the Second Millennium B.C. In V. Karageorghis, ed. *Acts of the International Archaeology Symposium "Cyprus between the Orient and the Occident"*. Nicosia: Department of Antiquities, Cyprus, pp. 45-62.

Müller, V., 2008. *Tell el-Dab$^{c}$a XVII: Opferdeponierungen in der Hyksoshauptstadt Auaris (Tell el-Dab$^{c}$a) vom späten Mittleren Reich bis zum Frühen Neuen Reich*, Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Mullins, R.A., 2006. A Corpus of Eighteenth Dynasty Egyptian-Style Pottery from Tel Beth-Shean. In A.M. Maier & P. de Miroschedji, eds. *"I Will Speak the Riddles of Ancient Times": Archaeological and Historical Studies in Honour of Amihai Mazar on the Occasion of His Sixtieth Birthday*. Winona Lake, IN: Eisenbrauns, pp. 247-262.

*Munsell Soil Color Charts*. 1954. Baltimore, Maryland: Munsell Color Company, Inc.

Murnane, W.J., 1985. *The Road to Kadesh: A Historical Interpretation of the Battle Reliefs of King Sety I at Karnak*, Chicago: University of Chicago Press.

Na'aman, N., 1981. Economic Aspects of the Egyptian Occupation of Canaan. *IEJ*, 31, 172-185.

Na'aman, N., 1994. The Hurrians and the End of the Middle Bronze Age in Palestine. *Levant*, 26, 175-87.

Nagel, G., 1938. *La Céramique du Nouvel Empire à Deir el Medineh, Tome I*, Le Caire: Institut Français d'Archéologie Orientale.

Newberry, P.E., 1893. *Beni Hasan, Part I*, London: Egypt Exploration Fund.

Newberry, P.E., 1900. *The Life of Rekhmara*, London: Butler and Tanner.

Nicholson, P. & Rose, P.J., 1985. Pottery Fabrics and Ware Groups at el-Amarna. In B. J. Kemp, ed. *Amarna Reports II*. London: Egypt Exploration Society, pp. 133-174.

Nordström, H. & Bourriau, J., 1993. Ceramic Technology: Clays and Fabrics. In Do. Arnold & J. Bourriau, eds. *An Introduction to Ancient Egyptian Pottery*. Mainz am Rhein: Verlag Phillip von Zabern, pp. 147-190.

Orel, S., 2000. A reexamination of the 1943-1952 excavations at Kom El-Hisn, Egypt. *Göttinger Miszellen*, 179, 39-49.

Oren, E.D., 1984. "Governors' Residences" in Canaan under the New Kingdom: A Case Study of Egyptian Administration. *JSSEA*, 14(2), 37-56.

Oren, E.D., 1987. The "Ways of Horus" in North Sinai. In A.F. Rainey,ed. *Egypt, Israel, Sinai: Archaeological and Historical Relationships in the Biblical Period*. Tel Aviv: Tel Aviv University, pp. 69-120.

Oren, E.D., 1993a. Tel Seraʿ. In E. Stern, ed. *The New Encyclopedia of Archaeological Excavations in the Holy Land, Vol. 4*. London: Simon & Schuster, pp. 1329-35.

Oren, E.D., 1993b. Northern Sinai. In E. Stern, ed. *The New Encyclopaedia of Archaeological Excavations in the Holy Land, Vol 4*. London: Simon & Schuster, pp. 1386-1396.

Oren, E.D., 1997. "The Kingdom of Sharuhen" and the "Hyksos Kingdom". In E.D. Oren, ed. *The Hyksos: New Historical and Archaeological Perspectives*. Philadelphia: University of Pennsylvania Museum, pp. 253-284.

Orton, C., 2000. *Sampling in Archaeology*. Cambridge Manuals in Archaeology. Cambridge: Cambridge University Press.

Orton, C., Tyers, P., & Vince, A., 1993. *Pottery in Archaeology*, Cambridge: Cambridge University Press.

Ownby, M.F., 2006. *Non-Destructive X-Ray Fluorescence Spectrometry of Marl C Sherds from Kahun, Egypt*. Unpublished MSc thesis, University College London.

Ownby, M.F. & Griffiths, D., 2009. The Petrographic Analysis of Beach Sand from Sidon to Determine its Utility for Ceramic Provenance Work. *Archaeology and History in the Lebanon*, 29, 56-67.

Özgüç, T., 2003. *Kültepe, Kaniš-Neša: the earliest international trade center and the oldest capital city of the Hittites*, Japan: The Middle Eastern Culture Center in Japan.

Papadopoulou, D.N., Zachariadis, G.A., Anthemidis, A.N., Tsirliganis, N.C., & Stratis, J.A., 2004. Microwave-assisted versus conventional decomposition procedures applied to a ceramic potsherd standard reference material by inductively coupled plasma atomic emission spectrometry. *Analytica Chimica Acta*, 505, 173-181.

Pape, A., 2001. Naturwissenschaftliche Untersuchungen zur Importkeramik aus dem Friedhof U in Abydos. In U.v. Hartung, ed. *Umm el-Qaab II: Imporkeramik aus dem Friedhof*

*U in Abydos (Umm el-Qaab) und die Beziehungen Ägyptens zu Vorderasien im 4. Jahrtausend v. Chr*. Mainz am Rhein: Verlag Phillip von Zabern, pp. 417-465.

Parr, P., 1973. The Origin of the Canaanite Jar. In D.E.Strong, ed. *Archaeological Theory and Practice*. London: Seminar, pp. 173-182.

Peacock, D.P.S., 1970. The Scientific Analysis of Ancient Ceramics: A Review. *World Archaeology*, 1(3), 375-389.

Peacock, D.P.S. ed., 1977. *Pottery and early commerce. Characterization and trade in Roman and later times,* London: Academic Press.

Pearlman, D., 1985. Kalavassos Village, Tomb 51: Tomb of an Unknown Soldier. *Report of the Department of Antiquities of Cyprus*, 164-79.

Perlman, I. & Asaro, F. ,1969. Pottery analysis by neutron activation. *Archaeometry*, 11, 21-52.

Petrie, C.A., Morris, J.C., Khan, F., Knox, J.R., & Thomas, K.D., 2007. The Dynamics of late Prehistoric Ceramic Production and Distribution in the Bannu and Gomal Regions, NWFP, Pakistan. *South Asian Studies*, 23, 75-94.

Petrie, W.M.F., 1890. *Kahun, Gurob, and Hawara,* London: Kegan Paul, Trench, Trübner, and Co.

Petrie, W.M.F., 1891. *Illahun, Kahun, and Gurob,* London: David Nutt.

Petrie, W.M.F., 1904. *Abydos, Part 3*, London: Egypt Exploration Fund.

Petrie, W.M.F., 1909a. *Memphis I*, London: British School of Archaeology in Egypt, University College.

Petrie, W.M.F., 1909b. *The Palace of Apries (Memphis II),* London: British School of Archaeology in Egypt, University College.

Petrie, W.M.F., 1911. *Roman portraits and Memphis IV,* London: British School of Archaeology in Egypt, University College.

Petrie, W.M.F., 1906. *Hyksos and Israelite Cities,* London: British School of Archaeology in Egypt, University College.

Petrie, W.M.F., 1931. *Ancient Gaza I: Tell el Ajjul,* London: British School of Archaeology in Egypt, University College.

Petrie, W.M.F., 1932. *Ancient Gaza II: Tell el Ajjul*, London: British School of Archaeology in Egypt, University College.

Petrie, W.M.F., 1933. *Ancient Gaza III: Tell el Ajjul*, London: British School of Archaeology in Egypt, University College.

Petrie, W.M.F., 1934. *Ancient Gaza IV: Tell el Ajjul*, London: British School of Archaeology in Egypt, University College.

Petrie, W.M.F., Mackay, E.J.H., & Murray, M.A., 1952. *City of shepherd kings. Ancient Gaza V: Tell el Ajjul*, London: British School of Archaeology in Egypt, University College.

Petrie, W.M.F., Mackay, E.J.H., & Wainwright, G., 1910. *Meydum and Memphis (III)*, London: British School of Archaeology in Egypt, University College.

Petrie, W.M.F., Wainwright, G., & Gardiner, A.H., 1913. *Tarkhan I and Memphis V*, London: British School of Archaeology in Egypt, University College.

Philip, G., 2006. *Tell el-Dab[c]a XV: Metalwork and Metalworking Evidence of the Late Middle Kingdom and the Second Intermediate Period*, Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Pierrat, G., 1994. À Propos de la Date et de l'Origine Du Trésor de Tôd. *Bulletin de la Societe Française de'Égypte*, 130, 18-27.

du Plat Taylor, J., 1957. *Myrtou Pigadhes: a late bronze age sanctuary in Cyprus*, Oxford: Department of Antiquities, Ashmolean Museum.

Polanyi, K., 1957. Marketless trading in Hammurabi's time. In K. Polanyi, C. Arensberg, & H. Pearson, eds. *Trade and Market in the Early Empires*. Glencoe: Free Press and Falcon's Wing Press, pp. 12-26.

Pollard, A.M. & Heron, C., 1996. *Archaeological Chemistry*, Cambridge: The Royal Society of Chemistry.

Polz, D., 2007. *Der Beginn des Neuen Reiches. Zur Vorgeschichte einer Zeitenwende*, Berlin: Walter de Gryuter.

Porada, E., 1982. Remarks on the Tôd Treasure in Egypt. In A. Dandamayev, ed. *Societies and Languages of the Ancient Near East, Studies in Honour of I.M. Diakonoff*. Warminster: Aris & Phillips, pp. 285-303.

Porat, N. & Goren, Y., 2001. Petrography of the Naqada IIIa Canaanite Pottery from Tomb U-j in Abydos. In U.v. Hartung, ed. *Umm el-Qaab II: Imporkeramik aus dem Friedhof U in Abydos (Umm el-Qaab) und die Beziehungen Ägyptens zu Vorderasien im 4. Jahrtausend v. Chr*. Mainz am Rhein: Verlag Phillip von Zabern, pp. 466-481.

Porat, N., Wintle, A.G., & Ritte, M., 2004. Mode and timing of kurkar and hamra formation, central coastal plain, Israel. *Israel Journal of Earth Sciences*, 53, 13-25.

Porat, N., Yellin, J., Heller-Kallai, L., & Halicz, L., 1991. Correlation between Petrography, NAA, and ICP Analyses: Application to Early Bronze Egyptian Pottery from Canaan. *Geoarchaeology*, 6, 133-149.

Porter, B. & Moss, R.L.B., 1952. *Topographical Bibliography of Ancient Egyptian Hieroglyphic Texts, Reliefs, and Paintings. VII. Nubia, the Deserts, and Outside Egypt*, Oxford: Griffith Institute, Ashmolean Museum.

Posener, G., 1940. *Princes et pays d'Asie et de Nubie: textes hiératiques sur des figurines d'envoûtement du Moyen Empire*, Bruxelles: Fondation égyptologique rein Élisabeth.

Posener, G., 1966. Les Textes D'envoutemont de Mirgissa. *Syria*, 43, 277-87.

Posener, G., 1971. Syria and Palestine c. 2160-1780 B.C. Relations with Egypt. In I. Edwards, C. Gadd, & N. Hammond, eds. T*he Cambridge Ancient History, Vol. 1., Part 2A: Early History of the Middle East., 3rd Ed*. Cambridge: Cambridge University Press, pp. 532-558.

Pritchard, J.B. ed., 1955. *Ancient Near Eastern Texts Relating to the Old Testament, 2$^{nd}$ Ed*., Princeton, N.J.: Princeton University Press.

Pulak, C., 1997. Uluburun Shipwreck. In S. Swiny, R.L. Hohlfedler, & H.W. Swiny, eds. *Res Maritimae: Cyprus and the Eastern Mediterranean from Prehistory to Late Antiquity. Proceedings of the Second International Symposium "Cities on the Sea", Nicosia, Cyprus, October 18-22, 1994*. American Schools of Oriental Research Archaeological Reports 4; Cyprus American Archaeological Research Institute Monographs 1. Atlanta: Scholars, pp. 233-62.

Quinn, P. ed., 2009. *Interpreting Silent Artefacts: Petrographic Approaches to Archaeological Ceramics*, Oxford: Archaeopress.

Quirke, S., 1991. Royal power in the 13th Dynasty. In S. Quirke, ed. *Middle Kingdom Studies*. New Malden: SIA Publishing, pp. 123-139.

Raban, A., 1980. *The Commercial Jar in the Ancient Near East: Its Evidence for Interconnections Amongst the Biblical Lands*. Unpublished Ph.D. Dissertation. Jerusalem, Hebrew University. [written in Hebrew].

Rainey, A., 1994. Review: Remarks on Donald Redford's "Egypt, Canaan, and Israel in Ancient Times". *BASOR*, 295, 81-85.

Rainey, A., 2006. Sinuhe's World. In A. Maier & P. de Miroschedji, eds. *"I Will Speak the Riddles of Ancient Times": Archaeological and Historical Studies in Honour of Amihai Mazar on the Occasion of His Sixtieth Birthday*. Winona Lake, IN: Eisenbrauns, pp. 277-299.

Randall-Maciver, D. & Woolley, C.L., 1911. *Buhen: text and plates*, Philadelphia: Pennsylvania University Museum.

Redford, D.B., 1979. A Gate Inscription from Karnak and Egyptian Involvement in Western Asia during the Early 18$^{th}$ Dynasty. *Journal of the American Oriental Society*, 99(2), 270-287.

Redford, D.B., 1992. *Egypt, Canaan, and Israel in Ancient Times*, Princeton: Princeton University Press.

Redford, D.B., 1996. A Response to Anson Rainey's "Remarks on Donald Redford's Egypt, Canaan, and Israel in Ancient Times". *BASOR*, 301, 77-81.

Redford, D.B., 1997. Textual Sources for the Hyksos Period. In E.D. Oren, ed. *The Hyksos: New Historical and Archaeological Perspectives*. Philadelphia, pp. 1-44.

Redford, D.B., 2003. *The Wars in Syria and Palestine of Thutmose III*, Leiden: Brill.

Redmount, C.A., 1989. *On an Egyptian/Asiatic Frontier: An Archaeological History of the Wadi Tumilat*. Unpublished PhD Dissertation, University of Chicago.

Redmount, C.A., 1993. Tell el-Maskhuta. Hyksos Pottery. *Bulletin de Liaison due Groupe International d'Étude de la Céramique Égyptienne*, XVII, 2-17.

Redmount, C.A., 1995a. Ethnicity, Pottery, and the Hyksos at Tell el-Maskhuta in the Egyptian Delta. *Biblical Archaeologist*, 58(4), 181-190.

Redmount, C.A., 1995b. Pots and Peoples in the Egyptian Delta: Tell El-Maskhuta and the Hyksos. *Journal of Mediterranean Archaeology*, 8(2), 61-89.

Renfrew, C.A., 1969. Trade and Cultural Process in European Prehistory. *Current Anthropology*, 10, 151-160.

Renfrew, C.A., 1986. Introduction: peer polity interaction and socio-political change. In C.A. Renfrew & J. Cherry, eds. *Peer Polity Interaction and Socio-political Change*. Cambridge: Cambridge University Press, pp. 1-18.

Renfrew, C.A., 1987. Report on the 1986 Excavations and survey: the survey of Site X2. In B.J. Kemp, ed. *Amarna Reports IV*. London: Egypt Exploration Society, pp. 87-102.

Renfrew, C.A. & Bahn, P., 2008. *Archaeology: Theories, Methods, and Practice, 5th Ed.*, London: Thames & Hudson.

Rice, P.M., 1987. *Pottery Analysis: A Sourcebook*, Chicago: The University of Chicago Press.

Roccati, A., 2002. A Stone Fragment Inscribed with the Names of Sesostris I Discovered at Qatna. In M. Al-Mazdissi, M. Luciani, D. Morandi, M. Novák, & P. Pfälzner,eds, *Excavating Qatna I, Preliminary report on the 1999 and 2000 campaigns of the joint Syrian-Italian-German archaeological research project at Tell Mishrifeh*. Damascus: Eberhard Karls Universität Tübingen, pp. 173-175.

Rose, P.J., 1987. Report on the 1986 Amarna Pottery Survey. In B.J. Kemp, ed. *Amarna Reports IV*. London: Egypt Exploration Society, pp. 115-131.

Rose, P.J., 2007. *The Eighteenth Dynasty Pottery Corpus from Amarna*, London: Egypt Exploration Society.

Rye, O.S., 1981. *Pottery Technology: Principles and Reconstruction*. Manuals on Archaeology 4. Washington DC: Taraxacum.

Rye, O.S., & Duerden, P., 1982. Papuan pottery sourcing by PIXE: Preliminary studies. *Archaeometry*, 24(1), 59-64.

Ryholt, K.S.B., 1997. *The Political Situation in Egypt during the Second Intermediate Period c. 1800-1550 B.C.*, Copenhagen: University of Copenhagen, Museum Tusculanum Press.

Ryholt, K.S.B., 1998. Hotepibre, a Supposed Asiatic King in Egypt with Relations to Ebla. *BASOR*, 311, 1-6.

Sabloff, J. & Lamberg-Karlovsky, C. eds., 1975. *Ancient Civilization and Trade*, Albuquerque: University of New Mexico.

Saghieh, M., 1983. *Byblos in the Third Millennium B.C. a Reconstruction of the Stratigraphy and a Study of the Cultural Connections*, Warminster: Aris & Phillips.

Saidah, R., 1993-1994. Beirut in the Bronze Age: The Kharji Tombs. *Berytus*, 41, 137-186.

Saint-Marc, P., 1974. Etude stratigraphique et micropaléontologique de l'Albien, du Cénomanien et du Turonien du Liban. *Notes et mémoires sur le Moyen-Orient*, 13, 9-298.

Sass, E., 1980. Late Cretaceous Volcanism in Mount Carmel, Israel. *Israel Journal of Earth Sciences*, 29, 8-24.

Sauvage, C., 2005. Quelques figures de commerçants d'après les texts égyptiens et ougaritiques, au Bronze Récent. In Ph. Clancier, ed. *Autour de Polanyi: vocabulaires, théories et modalités des échanges. Nanterre, 12-14 juin 2004.* Paris: De Boccard, pp. 155-170.

Scandone-Matthiae, G., 1997. The Relations Between Ebla and Egypt. In E.D. Oren,ed. *The Hyksos: New Historical and Archaeological Perspectives*. Philadelphia: University of Pennsylvania Museum, pp. 415-427.

Schaeffer, C.F-A., 1932. Les Fouilles de Minet-el-Beida et de Ras-Shamra. *Syria*, 13, 1-27.

Schaeffer, C.F-A., 1939. *Ugaritica I*, Paris: Librairie Orentaliste Paul Geuthner.

Schaeffer, C.F-A., 1949. *Ugaritica II*, Paris: Librairie Orentaliste Paul Geuthner.

Schiestl, R., 2000. Eine Archäologische Notiz: eine Neue Parallele zum Anhänger aus Tell el-Dab$^{c}$a aus dem Petrie Museum, University College London. *Ägypten und Levante*, X, 127-128.

Schiestl, R., 2002. Links between a Late Middle Kingdom Cemetery at Tell el-Dab$^{c}$a and Syria-Palestine: the Necropolis of F/I, Strata d/2 and d/1 (=H and G/4). In M. Bietak, ed. T*he Middle Bronze Age in the Levant, Proceedings of an International Conference on MB IIA Ceramic Material, Vienna, 24-26th of January 2001, CChEM 3*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 329-352.

Schiestl, R., 2006. The Statue of an Asiatic man from Tell el-Dab[c]a. *Ägypten und Levante,* XVI, 173-185.

Schiestl, R., 2009. *Tell el-Dab[c]a XVIII. Die Palastnekropole von Tell el-Dab[c]a. Die Gräber des Areals F/I der Straten d/2 und d/1,* Wien: Verlag der Österreichischen Akademie der Wissenschaften.

Schneider, T., 1998. *Ausländer in Ägypten während des Mittleren Reiches und der Hyksoszeit, Teil 1: die ausländischen Könige,* Wiesbaden: Otto Harrassowitz.

Schneider, T., 2003. *Ausländer in Ägypten während des Mittleren Reiches und der Hyksoszeit, Teil 2: Die ausländische Bevölkerung,* Wiesbaden: Otto Harrassowitz.

Schneider, T., 2006. The Relative Chronology of the Middle Kingdom and the Hyksos Period (Dyns. 12-17). In E. Hornung, R. Krauss, & D. Warburton, eds. *Ancient Egyptian Chronology*. Leiden: Brill, pp. 168–96.

Schortman, E. & Urban, P., 1987. Modeling Interregional Interaction in Prehistory. In M. Schiffer, ed. *Advances in Archaeological Method and Theory, Vol. 11*. New York: Academic Press, pp. 37-95.

Schortman, E. & Urban, P., 2000. Exchange Systems, Theory. In L. Ellis, ed. *Archaeological Method and Theory: An Encyclopedia*. New York, London: Garland Publishing, pp. 193-199.

Schwedt, A., Mommsen, H., & Zacharias, N., 2004. Post-Depositional Elemental Alterations in Pottery: Neutron Activation Analyses of Surface and Core Samples. *Archaeometry*, 46(1), 85-101.

Seiler, A.,1996. Keramik. In H. Jaritz, B. Dominicus, U. Minuth, W. Niederburger & A. Seiler, eds. Der Totentemple des Merenptah in Qurna 3. Grabungsbericht. *MDAIK*, 52, 201-232.

Seiler, A., 2005. *Tradition und Wandel. Die Keramik als Spiegel der Kulturentwicklung Thebens in der Zweiten Zwischenzeit*. Sonderschriften des Deutschen Archäologischen Instituts, Abteilung Kairo 32. Mainz am Rhein: Verlag Phillip von Zabern.

Serpico, M., 1996. *Mediterranean Resins in New Kingdom Egypt: A Multidisciplinary Approach to Trade and Usage*. Unpublished PhD thesis, University College London.

Serpico, M., 1999. New Kingdom Canaanite Amphorae Fragments from Buhen. In A. Leahy & J. Tait, eds. *Studies on Ancient Egypt in Honour of H.S. Smith*. London: Egypt Exploration Society, pp. 267-272.

Serpico, M., & White, R., 1998. Chemical analysis of coniferous resins from ancient Egypt using gas chromatography/mass spectrometry (GC/MS). In C.J. Eyre, ed. *Proceedings of the Seventh International Congress of Egyptologists, Cambridge, 3–9 September 1995*. Orientalia Lovaniensia Analecta 82. Leuven: Peeters, pp. 1039–48.

Serpico, M. & White, R., 2000. The Botanical Identity and Transport of Incense during the Egyptian New Kingdom. *Antiquity*, 74, 884-897.

Serpico, M., & White, R., 2001. The use and identification of varnish on New Kingdom funerary equipment. In W. V. Davies, ed. *Colour and painting in Ancient Egypt*. London: British Museum Press, pp. 33–42.

Serpico, M., Bourriau, J., Smith, L.M.V., Goren, Y., Stern, B. & Heron, C., 2003. Commodities and Containers: A Project to Study Canaanite Amphorae Imported into Egypt during the New Kingdom. In M. Bietak, ed. *The Synchronization of Civilizations in the Eastern Mediterranean in the Second Millennium B.C. II*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 365-376.

Sethe, K., 1926. *Die Achtung feindlicher Fürsten, Volker und Dinge auf altägyptischen Tongefasscherben des mittleren Reiches: nach den Originalen im Berliner Museum*, Berlin: Akademie der Wissenschaften in Kommission bei W. de Gruyter.

Seyfried, K., 1981. *Beiträge zu den Expeditionen des Mittleren Reiches in de Ost-Wüste*, Hildesheim: Gerstenberg Verlag.

Shaw, I. ed., 2000. *The Oxford History of Ancient Egypt*, Oxford: Oxford University Press.

Shaw, J.W., 1981. Excavations at Kommos (Crete) during 1980. *Hesperia*, 50(3), 211-252.

Shaw, J.W., 1982. Excavations at Kommos (Crete) during 1981. *Hesperia*, 51(2), 164-195.

Shaw, J.W., 1986. Excavations at Kommos (Crete) during 1984-1985. *Hesperia*, 55(3), 219-269.

Shennan, S., 1997. *Quantifying Archaeology, 2nd Ed.*, Edinburgh: Edinburgh University Press.

Shepard, A.O., 1942. *Rio Grande Glaze Paint Ware, A Study Illustrating the Place of Ceramic Technological Analysis in Archaeological Research*, Washington D.C.: Carnegie Institution of Washington.

Shepard, A.O., 1956. *Ceramics for the Archaeologist*, Washington D.C.: Carnegie Institution of Washington.

Shepard, A.O., 1966. Rio-Grande glaze-paint pottery: a test of petrographic analysis. In F.R. Matson, ed. *Ceramics and Man*. London: Methuen, pp. 62-87.

Sherratt, E. & Sherratt, A., 1991. From Luxuries to Commodities: the Nature of Mediterranean Bronze Age Trading Systems. In N. Gale, ed. *Bronze Age Trade in the Aegean*. Jonsered: Paul Åströms Förlag, pp. 351-386.

Singer-Avitz, L., 2004. The Middle Bronze Age Pottery from Areas D and P (Ch. 15) and The Middle Bronze Age Cemetery (Ch. 17). In D. Ussishkin, ed. *The Renewed Archaeological Excavations at Lachish (1973-1994), Vol. III*. Tel Aviv: Emery and Claire Yass Publications in Archaeology, Institute of Archaeology, Tel Aviv University, pp. 900-965 and 971-1011.

Sinopoli, C.M., 1993. *Pots and palaces: the earthenware ceramics of the nobleman's quarter of Vijayanagara*, New Delhi: Manohar and American Institute of Indian Studies.

Sivan, D., 1996. *Paleogeography of the Galilee coastal plain during the Quaternary*. Report GSI/18/96. Jerusalem: Geological Survey of Israel. (English Summary).

Sivan, D., Gvirtzman, G. & Sass, E., 1999. Quaternary Stratigraphy and Paleogeography of the Galilee Coastal Plain, Israel. *Quaternary Research*, 51, 280-94.

Skoog, D.A., Holler, F.J., & Nieman, T.A., 1998. *Principles of Instrumental Analysis, 5th Ed.*, Philadelphia: Saunders College Publishing.

Smith, H.S., 1976. *The Fortress of Buhen II: the Inscriptions*, London: Egypt Exploration Society.

Smith, L.M.V., Bourriau, J. & Serpico, M., 2000. The provenance of Late Bronze Age transport amphorae found in Egypt. *Internet Archaeology*, 9.

Smith, L.M.V., Bourriau, J., Goren, Y., Hughes, M.J. & Serpico, M., 2004. The Provenance of Canaanite Amphorae found at Memphis and Amarna in the New Kingdom: results 2000-2002. In J. Bourriau & J. Phillips, eds. *Invention and Innovation: The Social Context of Technological Change 2, Egypt, the Aegean and the Near East, 1650-1150 BC*. Oxford: Oxbow Books, pp. 55-77.

Smith, S.T., 1995. *Askut in Nubia: the economics and ideology of Egyptian imperialism in the second millennium B.C.*, London: Kegan Paul International.

Smith, W.S., 1965. *Interconnections in the Ancient Near East*, New Haven: Yale University Press.

Snape, S., 2000. Imported Pottery at Zawiyet Umm el-Rakhma, Preliminary Report. *Bulletin de Liaison due Groupe International d'Étude de la Céramique Égyptienne*, XXI, 17-20.

Snape, S.R., 2003. Zawiyet Umm el-Rakham and Egyptian Foreign Trade in the 13th Century BC. In N. Chr. Stampolidis & V. Karageorghis, eds. *Sea Routes . . . Interconnections in the Mediterranean 16th-6th c. BC. Proceedings of the International Symposium Held at Rethymnon, Crete, September 29th – October 2nd, 2002*. Athens: University of Crete and Leventis Foundation, pp. 63-70.

Snape, S. & Wilson, P., 2007. *Zawiyet Umm el-Rakham*, Bolton: Rutherford Press.

Sneh, A., Bartov, Y., & Rosensaft, M., 1998a. *Geological Map of Israel, 1:200,000, Sheet 1*, Jerusalem: Geological Survey of Israel.

Sneh, A., Bartov, Y., & Rosensaft, M., 1998b. *Geological Map of Israel, 1:200,000, Sheet 2*, Jerusalem: Geological Survey of Israel.

Soete, D. de, Gijbels, R. & Hoste, J., 1972. *Neutron Activation Analysis*, London and New York: Wiley-Interscience.

South, A.K., Russell, P. & Schuster Keswani, P., 1989. *Vasilikos Valley Project 3: Kalavassos-Ayios Dhimitrios II: Ceramics, Objects, Tombs, Specialist Studies*, Göteborg: Paul Åströms Förlag.

Sparks, R.T., 1998. *Stone Vessels in the Levant During the Second Millennium B.C.: A Study of the Interaction Between Imported Forms and Local Workshops*. Unpublished PhD Dissertation, University of Sydney.

Stager, L.E., 1993. Ashkelon. In E. Stern, A. Lewison-Gilboa & J. Aviram, eds. *The New Encyclopaedia of Archaeological Excavations in the Holy Land, Vol. 1.* London: Simon & Schuster, pp. 103-112.

Stager, L.E., 2001. Port Power in the Early and the Middle Bronze Age: The Organization of Maritime Trade and Hinterland Production. In S. Wolff, ed. *Studies in the Archaeology of Israel and Neighboring Lands*. Chicago: American Schools of Oriental Research, Oriental Institute of the University of Chicago, pp. 625-638.

Stager, L.E., 2002. The MB IIA Ceramic Sequence at Tel Ashkelon and Its Implications for the "Port Power" Model of Trade. In M. Bietak, ed. T*he Middle Bronze Age in the Levant, Proceedings of an International Conference on MB IIA Ceramic Material, Vienna, 24-26th of January 2001, CChEM 3*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 353-362.

Stampolidis, N. Chr. & Karageorghis, V. eds, 2003. *Sea Routes . . . Interconnections in the Mediterranean 16$^{th}$-6$^{th}$ c. BC. Proceedings of the International Symposium Held at Rethymnon, Crete, September 29$^{th}$ – October 2$^{nd}$, 2002*, Athens: University of Crete and Leventis Foundation.

Sterba, J.H., Mommsen, H., Steinhauser, G., & Bichler, M., 2009. The influence of different tempers on the composition of pottery. *JAS*, 36(7), 1582-1589.

Stern, B., Heron, C., Corr, L., Serpico, M. & Bourriau, J., 2003. Compositional Variations in Aged and Heated Pistacia Resin found in Late Bronze Age Canaanite Amphorae and Bowls from Amarna, Egypt. *Archaeometry*, 45, 457-469.

Stern, B., Heron, C., Tellefsen, T., & Serpico, M., 2008. New investigations into the Uluburun resin cargo. *JAS*, 35, 2188-2203.

Stern, E., 1993. Tel Dor. In E. Stern, A. Lewison-Gilboa, A. & J. Aviram, eds.*The New Encyclopaedia of Archaeological Excavations in the Holy Land, Vol. 1*. London: Simon & Schuster, pp. 357-368.

Stienstra, P., 1986. Systematic Macroscopic Description of the Texture and Composition of Ancient Pottery – Some Basic Methods. *Newsletter of the Department of Pottery Technology of Leiden*, IV, 29-48.

Streeten, A.D.F., 1982. Textural Analysis: An Approach to the Characterisation of Sand-Tempered Ceramics. In I.C. Freestone, C. Johns, & T. Potter, eds. *Current research in ceramics: thin-section studies*. London: British Museum, pp. 123-134.

Swiny, S., Hohlfedler, R.L., & Swiny, H.W. eds, 1997. *Res Maritimae: Cyprus and the Eastern Mediterranean from Prehistory to Late Antiquity. Proceedings of the Second International Symposium "Cities on the Sea", Nicosia, Cyprus, October 18-22, 1994*. American Schools of Oriental Research Archaeological Reports 4; Cyprus American Archaeological Research Institute Monographs 1. Atlanta: Scholars.

Symeonoglou, S., 1985. *The Topography of Thebes from the Bronze Age to Modern Times*, Princeton: Princeton University.

Szafranski, Z., 2002. An Argument on the Synchronization of Middle Bronze Age IIA and the Late Middle Kingdom in Egypt. In E.D. Oren & S. Ahituv, eds. *Aharon Kempinski Memorial Volume: Studies in Archaeology and Related Disciplines*. Beer Sheva: Ben-Gurion University of the Negev Press, pp. 360-367.

Tallet, P., 2003. New Jar Labels from Deir al-Medina. In Z. Hawass, ed. *Egyptology at the Dawn of the 21st Century, Proceedings of the Eight International Congress of Egyptologists, Cairo 2000, Vol. I. Archaeology*. Cairo: American University in Cairo Press, pp. 495-498.

Teissier, B., 1996. *Egyptian Iconography on Syro-Palestinian Cylinder Seals of the Middle Bronze Age*. Orbis Biblicus et Orientalis Series Archaeologica 11. Fribourg: University Press; Göttingen: Vandenhoeck & Ruprecht.

Thalmann, J.-P., 2002. Pottery of the Early Middle Bronze Age at Tell Arqa and in the Northern Levant. In M. Bietak, ed. *The Middle Bronze Age in the Levant, Proceedings of an International Conference on MB IIA Ceramic Material, Vienna, 24-26th of January 2001, CChEM 3*, Vienna. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 363-377.

Thalmann, J.-P., 2003. Transporter et Conserver: Jarres de l'Âge du Bronze à Tell Arqa. *Archaeology and History in Lebanon*, 17, 25-37.

Thalmann, J.-P., 2006. *Tell Arqa-1. Les niveaux de l'âge du Bronze*, Beyrouth: Institut Français d'Archéologie du Proche-Orient.

Thalmann, J.-P. 2008. Tell Arqa et Byblos, Essai de correlation. In M. Bietak & E. Czerny, eds. *The Bronze Age in the Lebanon. Studies on the Archaeology and Chronology of Lebanon, Syria, and Egypt*. Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 61-78.

Thomas, S., 2003. Imports at Zawiyet Umm al-Rakham. In Z. Hawass, ed. *Egyptology at the Turn of the Twenty-first Century. Proceedings of the Eight International Congress of Egyptologists, Cairo 2000, I. Archaeology*. Cairo: American University in Cairo Press, pp. 522-529.

Thompson, M. & Walsh, J.N., 1989. *Handbook of Inductively Coupled Plasma Spectrometry*, Glasgow: Blackie.

Tite, M., 1999. Pottery Production, Distribution, and Consumption: The Contribution of the Physical Sciences. *Journal of Archaeological Methods and Theory,* 6 (3), 181-233.

Tsolakidou, A. & Kilikoglou, V., 2002. Comparative analysis of ancient ceramics by neutron activation analysis, inductively coupled plasma-optical-emission spectrometry, inductively coupled plasma-mass spectrometry, and X-ray fluorescence. *Analytical and Bioanalytical Chemistry*, 374(3), 566-572.

Tsolakidou, A., Buxeda i Garrigos, J., & Kilikoglou, V., 2002. Assessment of dissolution techniques for the analysis of ceramic samples by plasma spectrometry. *Analytica Chimica Acta*, 474, 177-188.

Tubb, J., 1983. The MBIIA Period in Palestine: Its Relationship with Syria and Its Origin. *Levant*, 15, 49-62.

Tufnell, O., 1958. *Lachish IV (Tell ed-Duweir) The Bronze Age*, Oxford: Oxford University Press.

Tufnell, O., 1962. The Courtyard Cemetery at Tell el-ʻAjjul, Palestine. *Bulletin of the Institute of Archaeology,* 3, 1-37.

Tufnell, O., 1969. The Pottery from Royal Tombs I-III at Byblos. *Berytus*, 18, 5-33.

Tufnell, O., 1980. A Review of the Contents of Cave 303 at Tell el-ʿAjjul. *ʻAtiqot*, 14, 47-48.

Tufnell, O., & Ward, W.A., 1966. Relations between Byblos, Egypt, and Mesopotamia at the End of the Third Millennium BC. *Syria*, 43, 165-241.

Van De Mieroop, M., 2007. *A History of the Ancient Near East, ca. 3000-323 BC, 2nd Ed.*, Oxford: Blackwell.

Van Seters, J., 1966. *The Hyksos: a new investigation*, New Haven: Yale University Press.

Vaughn, S.J., 1995. Ceramic Petrography. *AJA*, 99, 115-117.

Vercoutter, J., 1962. Preliminary Report on the Excavations at Aksha by the Franco-Argentine Archaeological Expedition. *Kush*, 10, 109-116.

Vincentelli, I., 2006. *Hillat el-Arab: the joint Sudanese-Italian expedition in the Napatan Region, Sudan*, Oxford: Archaeopress.

Wallerstein, I., 1974. *The Modern World-System I*, New York: Academic Press.

Wallerstein, I., 1980. *The Modern World-System II*, New York: Academic Press.

Ward, W.A., 1971. *Egypt and the East Mediterranean World 2200-1900 B.C.: Studies in Egyptian Foreign Relations during the First Intermediate Period*, Beirut: American University of Beirut.

Ward, W.A., 1993-1994. Egyptian Objects from the Beirut Tombs. *Berytus*, 41, 211-221.

Watrous, L.V., 1992. *Kommos III: the late Bronze Age pottery*, Princeton, N.J.: Princeton University Press.

Weinstein, J.M., 1974. A Statuette of the Princess Sobeknefru at Tell Gezer. *BASOR*, 213, 49-57.

Weinstein, J.M., 1975. Egyptian Relations with Palestine in the Middle Kingdom. *BASOR*, 217, 1-16.

Weinstein, J.M., 1981. The Egyptian Empire in Palestine: A Reassessment. *BASOR*, 241, 1-28.

Weinstein, J.M., 1982. Review of "The Origin and Distribution of Tell el-Yahudiyeh Ware" by Maureen F. Kaplan. (Studies in Mediterranean Archaeology 62.) Paul Åströms Förlag, Göteborg 1980. *AJA*, 86(3), 450-452.

Weinstein, J.M., 1991. Egypt and the Middle Bronze IIC/Late Bronze IA Transition in Palestine. *Levant*, 23, 105-115.

Weinstein, J.M., 1992a. The Chronology of Palestine in the Early Second Millennium B.C.E. *BASOR*, 288, 27-46.

Weinstein, J.M., 1992b. The Collapse of the Egyptian Empire in the Southern Levant. In W.A. Ward & M.S. Jukowsky, eds. *The Crisis Years: The 12$^{th}$ Century B.C. From beyond the Danube to the Tigris*. Dubuque, IA: Kendall/Hunt, pp. 142-50.

Weinstein, J.M., 1995. Reflections on the Chronology of Tell el-Dab$^{c}$a. In W. Davies & L. Schofield, eds. *Egypt, the Aegean and the Levant. Interconnections in the Second Millennium BC*. London: British Museum Press, pp. 84-90.

Weinstein, J.M., 1997. Tell el-Yahudiyeh. In E. Myers, ed. T*he Oxford Encyclopedia of Archaeology in the Near East, Vol. 5*. Oxford: Oxford University Press, pp. 368-369.

Weinstein, J.M., 1998. Egyptian Relations with the Eastern Mediterranean World at the End of the Second Millennium BCE. In S. Gitin, A. Mazar, & E. Stern, eds. *Mediterranean Peoples in Transition: Thirteenth to Early Tenth Centuries BCE*. Jerusalem: Israel Exploration Society, pp. 188-196.

Wetzel, R., 1945. *Carte géologique au 50.000$^{e}$ Feuille de Tripoli*, Beyrouth: Ministére des Travaux Publics, République Libanaise.

Whitbread, I.K., 1989. A Proposal for the Systematic Description of Thin Sections towards the Study of Ancient Ceramic Technology. In Y. Maniatis, ed. *Archaeometry: Proceedings of the 25th International Symposium*. New York: Elsevier, pp. 127-138.

Whitbread, I.K., 1991. Image and Data Processing in Ceramic Petrology. In A.P. Middleton & I.C. Freestone, eds. *Recent Developments in Ceramic Petrology*. British Museum Occasional Paper No. 81. London: British Museum Press, pp. 369-388.

Whitbread, I.K., 1995. *Greek transport amphorae: a petrological and archaeological study*. Fitch Laboratory Occasional Paper 4. Athens: British School at Athens.

White, D., 2003. Multum in Parvo: Bates's Island on the NW Coast of Egypt. In N. Chr. Stampolidis & V. Karageorghis, eds. *Sea Routes . . . Interconnections in the Mediterranean 16th-6th c. BC. Proceedings of the International Symposium Held at Rethymnon, Crete, September 29th – October 2nd, 2002*. Athens: University of Crete and Leventis Foundation, pp. 71-81.

Whitechurch, H., Juteau, T., & Montigny, R., 1984. Role of Eastern Mediterranean ophiolites (Turkey, Syria, Cyprus) in the history of the Neo-Tethys. In J.E. Dixon & A.H.F. Robertson, eds. *The Geological Evolution of the Eastern Mediterranean*. Oxford: The Geological Society, pp. 301-317.

Wieder, M., & Adan-Bayewitz, D., 2002. Soil Parent Materials and the Pottery of Roman Galilee: A Comparative Study. *Geoarchaeology,* 17, 393-415.

Williams, B.B., 1992. *Excavations between Abu Simbel and the Sudan Frontier, Part 6: New Kingdom Remains from Cemeteries R, V, S, and W at Qustul and Cemetery K at Adindan*, Chicago: The Oriental Institute of the University of Chicago.

Wilson, A.L., 1978. Elemental Analysis of Pottery in the Study of its Provenance: A Review. *JAS*, 5, 219-236.

Wood, B.G., 1987. Egyptian Amphorae of the New Kingdom and Ramesside Periods. *Biblical Archaeologist*, 50, 75-83.

Woolley, C.L., 1955. *Alalakh. An account of the excavations at Tell Atchana in the Hatay, 1937-1949,* Oxford: O.U.P. for the Society of Antiquaries.

Yaalon, D.H. & Dan, J., 1967. Factors controlling soil formation and distribution in the Mediterranean coastal plain of Israel during the Quaternary. In R.B. Morrison & H.E. Wright, eds. *Quaternary Soils. Proceedings of the VII Congress of the International Association for Quaternary Research*. Reno, Nevada: Center for Water Resources Research, Desert Research Institute, University of Nevada, pp. 321-338.

Yacoub, F., 1983. Excavations at Tell Farasha. *ASAE*, 65, 175-176.

Yannai, E., 2004. The Late Bronze Age Pottery from Area S. In D. Ussishkin, ed. *The Renewed Archaeological Excavations at Lachish (1973-1994), Vol. III*. Tel Aviv: Emery and Claire Yass Publications in Archaeology, Institute of Archaeology, Tel Aviv University, pp. 1032-1146.

Yon, M., 2006. *The City of Ugarit at Tell Ras Shamra*, Winona Lake, IN: Eisenbrauns.

Zeeb, F., 2004. The History of Alalakh as a Testcase for an Ultrashort Chronology of the Mid-2nd Millennium B.C.E. In H. Hunger & R. Pruzsinszky,eds, *Mesopotamian Dark Age revisited: proceedings of an International Conference of SCIEM 2000 (Vienna, 8th-9th November 2002).* Wien: Verlag der Österreichischen Akademie der Wissenschaften, pp. 81-95.

Zemer, A., 1978. *Storage Jars in Ancient Sea Trade*, Haifa: National Maritime Museum Foundation.

# Appendix I: Analytical Protocols

## I Macroscopic Protocol

### I.1 Sherd Preparation

For each sherd, a chip perpendicular to the vessel wall was removed with pliers to expose the cross-section[211]. A fresh chip as opposed to a sawn edge was examined because it reveals grains in three dimensions that often facilitate identification (Stienstra 1986: 35). The procedures for the examination of the chips followed those outlined in Bourriau & Nicholson (1992) and Bourriau *et al.* (2000).

### I.2 Macroscopic Examination

The macroscopic examination employed a Leica Wild M420 stereoscope and a magnification of 25x. This magnification was chosen since the in-field descriptions were based on the examination of a fresh break with the same magnification. Additionally, a magnification this high would help to relate the characteristics of the fabric to the features seen at 100x magnification in the petrographic thin sections.

### I.3 Description Procedures

For each sherd chip, a form (Fig. I.1) was completed with the following information: date in antiquity, fabric designation, sherd number, provenance (RAT number), and comments that could include information about distribution, relationship to other fabrics, distinctive properties, or problems encountered. The fabric was described by the type, size, and prevalence of inclusions, the sorting, the porosity, and the structure/hardness. Additionally, the wall thickness was measured in millimetres and the colour of the fracture (including zones if present) and surfaces was determined with Munsell Soil Color Charts (1954).

The inclusion types listed on the form consisted of sand (quartz/feldspar), plant remains, limestone, shell strips, microfossils, mica, grog, rounded sand grains, grey-white particles, red-brown soft particles, red-brown rock particles, black rock particles, and any other inclusions identified. The size of the inclusions was measured with the lens graticule and classified as fine (60-250 microns), medium (250-500 microns), and coarse (>500 microns). However, a separate size designation system was used for the larger plant remains: fine, <2mm; medium, 2-5 mm; and coarse, >5 mm. The frequency of inclusions was determined for each size category and coded as (1) few inclusions, (2) common inclusions,

[211] This procedure and some of the description of the fabric followed Stienstra 1986.

and (3) abundant particles that often touch. The sorting of the inclusions was classified as very good, good, fair, poor, or very poor (Fig. I.2)

Porosity was designated as incipient vitrification, dense, medium, or open. The hardness of the fabric was usually determined when the chip was taken from the sherd (Stienstra 1986: 35). The hardness could be either hard, medium hard, or crumbly, and the presence of decomposed limestone particles and/or elongated pores was also noted under this section. This is because several variables will affect the hardness of a sherd, such as the mineral inclusions, range in grain sizes, porosity, and the temperature of firing (Stienstra 1986: 38). All of the above information was entered into a database in Microsoft Access in addition to being recorded on the forms.

Fig. I.1: Fabric description form

FABRIC DESCRIPTION

NO. DATE

COMMENTS: distribution; problems; relationship to other fabrics; distinctive properties.

Sherd No. Provenance

Photographs

Thin Sections

PROPERTIES

Magnification Microscope

INCLUSIONS:

| Sand- (quartz/felspar) | | Plant- Remains | | Limestone- | |
|---|---|---|---|---|---|
| Fine 60-250mi | [ ] | Fine<2mm | [ ] | Fine 60-250mi | [ ] |
| Medium 250-500mi | [ ] | Medium 2-5mm | [ ] | Medium 250-500mi | [ ] |
| Coarse >500mi | [ ] | Coarse >5mm | [ ] | Coarse >500mi | [ ] |

Grey-white particles Red-brown particles, soft

Mica Red-brown rock particles,

Shell: strips Microfossils Rounded sand-grains

Grog Black-rock particles

Other

SORTING: Very Poor ; Poor ; Fair ; Good ; Very Good .

POROSITY:Open ;Medium ;Dense ;Incipient vitrification

STRUCTURE/HARDNESS: Crumbly ;Medium hard ;Hard

Decomposed limestone particles . Elongated pores

WALL THICKNESS:Thin 2-4mm ;Medium 5-9mm ;Thick 10-19mm ;>19mm

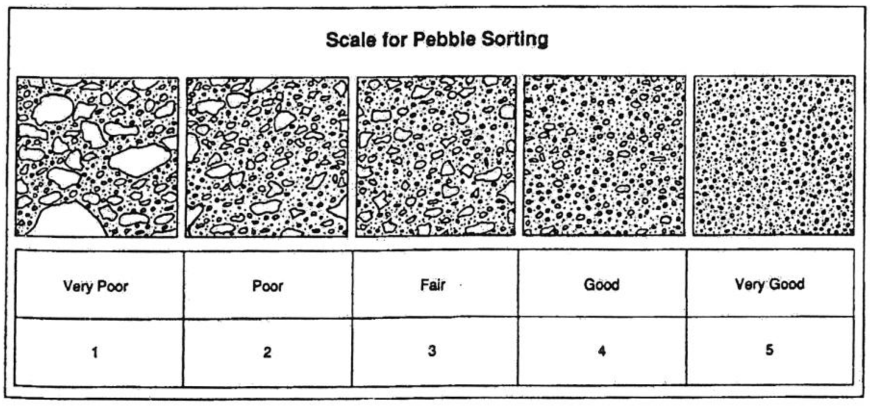
FIRING/COLOUR: Fracture: Zones Colour

No Zones Colour

Comment

Surface: Colour

Fig. I.2: Sorting chart




## *II Production of Ceramic Thin Sections Protocol*

### II.1 Discussion of Techniques

The techniques used to make ceramic thin sections are based on the methods for making rock thin sections within the Geological Sciences. To date, there is no established standard protocol for the manufacture of ceramic thin sections, with various labs/individuals developing independent techniques. This is due to the variability in ceramics, requiring slightly different methods depending on their individual characteristics. Therefore, having several different procedures on hand that can be tailored to the material being examined is common. Unfortunately, how the material will behave during thin section production is difficult to determine until after an attempted has been made. Then the procedures can be adjusted accordingly. Because of these inherent difficulties, an outline of the protocols employed in this study is presented and the methods, results, and number of sections manufactured by the techniques are discussed[212].

### II.2 Manufacturing Technique 1

The first method for producing ceramic thin sections was based on Mr. Simon Groom's procedures at the Institute of Archaeology, University College London[213].

- A thin slice of the sherd was taken with a Buehler saw and a diamond coated blade
- The slice was polished flat with a grinding wheel and final polishing was achieved with glass plates and aluminium oxide polishing powder.

212 As stated in Chapter 3, a minimum of two thin sections were made for each of the 56 sherds.
213 I am appreciative to Mr. Groom for his help in working with his methodology.

- The sherd slice was then glued to a small slide with glue activated by UV light and placed under a press.
- Once the glue was set, the slide was placed on the Buehler Petrothin Thin Sectioning System and ground down to 60 microns. The required thickness of 30 microns (0.03mm) was achieved with the glass plates and polishing powder.

In attempting this procedure with test materials problems were encountered at several stages. First, the UV glue did not completely harden, although various UV sources and durations of exposure were tested. Second, after the glue appeared to set and the section had been ground down, air would infiltrate between the sherd slice and the slide. These issues resulted in abandoning this procedure and none of the MBA Canaanite jar sections were made using this protocol.

### II.3 Manufacturing Technique 2

The second methodology was based on the process developed by Mr. Harry Williams at the Department of Geology, University of Manchester.

- Impregnate the surface of a sherd slice placed on a hot plate with a mixture of Aradur resin and hardener. Once the resin was not tacky, it could be scraped off with a razor blade and the surface of the slice ground by a few micrometers.
- The sample was placed under a press sitting on a hot plate. A mixture of Epotek resin and hardener was used for gluing the sherd slice to the slide.
- The section was thinned to 30 microns by the same process as in manufacturing technique 1.

Difficulties arose in this technique in utilizing the hot plates for both the surface impregnation and the gluing of the sample to the slide, and eventually they were eliminated from the procedure. While this made the methodology easier to accomplish, problems began to arise with large air holes developing between the slide and the sherd slice. This phenomenon is probably due to 1) difficulties in the surface impregnation, 2) grinding too much of the surface off after impregnation, 3) the force of the press being too great, and 4) differences in porosity between the sherds. All of these factors contributed to the presence of air between the section and the slide; an issue that could lead to the sample coming off the slide at a later point. Therefore, this procedure also had to be discarded. However, 24 MBA Canaanite jar thin sections were produced utilizing this technique[214].

[214] Five sections were produced utilizing a method for making soil thin sections employed by Ms. Julie Boreham. These also proved to be problematic and the method was abandoned.

### II.4 Manufacturing Technique 3

A successful process for making ceramic thin sections was established with the advice of Ms. Alice Hunt at the Institute of Archaeology, UCL[215]. The following explanation is the finalized procedures employed for producing the ceramic thin sections of the MBA Canaanite jars from Memphis.

- A 1 cm thick slice was cut from each sherd using an Isomet 1000 Precision saw rotating at 100 rpms. This saw was fitted with a diamond blade (Buehler 15.2 x 0.5 mm Wafering Blade, series 15 LC Diamond).
- The slices were then placed into plastic moulds coated with a releasing agent. A mixture of Epo-thin resin, Epo-thin hardener, and acetone was poured into the moulds. These moulds were then placed in a vacuum chamber under -70 Kpa pressure for twenty-four hours. This ensured all of the resin infiltrated the pore spaces within the sherd slice.
- Once the moulds had been removed from the vacuum chamber, they were placed in a fume cupboard for an additional 48 hours in order for the resin to set completely.
- The resin blocks were removed from the moulds and the bottom surface ground to expose the flattened sherd slice. A Buehler Motopol 2000 grinder/polisher with a 203 mm diamond platen was used to grind the samples. The ground surface was then polished on glass plates with first a 600-grit aluminium oxide powder, and then a 14.5-micron aluminium oxide powder. The excess resin was cut off and the other side of the resin block was ground flat so that the samples would be even under the press. For the second set of thin sections, the prepared resin blocks were placed in beakers filled with industrial methylated spirits (IMS) that were placed in a sonicator and agitated for 3 minutes. This was to remove any aluminium powder and microscopic pieces of pottery from the surface of the sherd slice before it was glued to the slide.
- The same mixture of Epo-thin resin, Epo-thin hardener, and acetone was employed for gluing the sample resin blocks to slides measuring 25x75 mm and 1 mm thick. The slides were then placed under the press with the sample facing upwards. The weight of the piston was cushioned using a 1 cm thick foam pad directly placed on top of the sample. A metal plate was then placed on the foam

[215] I am indebted to Ms. Hunt for her enormous assistance in this matter.

pad to distribute the force of the piston evenly across the sample. The samples remained under the press for a minimum of 24 hours. Once taken off the press, the excess resin was removed with acetone.

- The thickness of the sample was reduced to around 70 microns with a Buehler Petrothin Thin Sectioning System. The final step was to polish the section down to 30 microns with the 14.5-micron aluminium powder on a glass plate.
- The samples were left without a cover slip for possible future electron microprobe analysis.

This procedure proved extremely effective because all of the pore space in the sherd slices was filled with resin, preventing air from coming between the slice and the slide. The technique was used to make 90 thin sections of the MBA Canaanite jars.

## *III Petrographic Microscopy Protocol*

### III.1 Petrographic Microscope Examination

Methods for analyzing thin sections of ceramics have most clearly been described by Whitbread (1989, 1995: 365-396). Additional methods used for this study were based on the published ceramic thin section descriptions by Bourriau & Nicholson (1992) and Bourriau *et al.* (2000). In particular, it was important that the results be comparable to the descriptions of the LBA Canaanite jars from Memphis (Bourriau *et al*. 2001, Smith *et al*. 2004). For each thin section, a form was completed listing the sample number, thin section number, fabric designation, date of examination, the microscope employed, and the magnifications utilized. All of the thin sections were examined with various magnifications using a Nikon Optiphot Polarizing Microscope with attached mechanical stage. The stage allowed the thin sections to be scanned in measured increments at 100x magnification to identify the constituents. The coordinates of each transect for scanning the thin section were recorded on the form.

### III.2 Thin section Description

The thin sections were initially examined at 40x magnification and the colour of the section in plane polarized light (PPL) and cross polarized light (XPL) was determined. The optical activity of the matrix was recorded as, inactive, slightly active, or active[216]. The presence of a mineral or inclusion type was noted along with whether it occurred in the silt-sized fraction (i.e. less than 0.0625 mm). Rock fragments were described separately by type and the degree of weathering (specifically for basalt inclusions) was assessed. For the

[216] Optical activity refers to changes in the appearance of the thin section matrix as the stage is rotated and is a good measure for the degree of vitrification due to firing (Whitbread 1995: 382).

inclusions of quartz/feldspars, limestone, and chert, the size of the grains and their frequency was recorded. Grain size was determined utilizing the eyepiece graticule and categorized as seen in Table I.1. Frequency was designated as very rare (1-5 grains), rare (c. 10% of inclusions), sparse (c. 10-25%), frequent (c. 25-50%), abundant (c. 50-75%), and highly abundant (c. > 75%). The shape of the grains of quartz/feldspar and limestone were assessed using Power's Scale of Roundness for grains of high and low sphericity (Fig. I.3, Barraclough 1992).

Description of the overall fabric included sorting, the estimated percentage of inclusions and the general type of the clay. Sorting could be very poor, poor, fair, good, or very good (Fig. I.2, Barraclough 1992). The percentage of inclusions, determined as the amount of inclusions within the clay matrix above silt-size minus voids, was divided into categorizes based on size range (i.e. 0.5-1 mm, 0.5-2 mm, 0.5-3 mm). Within each of these groups, the percentage of inclusions could be <5%, 5%, 10%, 20-30% or >30% (Fig. I.4, Matthew *et al.* 1991: 217, 219). The clay types were identified using visual criteria based on the work of Wieder & Adan-Bayewitz (2002) and through examination of comparative material from the Levant[217].

Table I.1: Size ranges for inclusions

| Size Range | Grain Sizes | Code |
|---|---|---|
| Very fine | 0.0625 - 0.125 mm | 1.0 |
| Fine | 0.125 - 0.25 mm | 2.0 |
| Medium | 0.25 - 0.5 mm | 3.0 |
| Coarse | 0.5 - 1 mm | 4.0 |
| Very coarse | 1 - 2 mm | 5.0 |
| Very fine to fine | 0.0625 - 0.25 mm | 1.1 |
| Very fine to medium | 0.0625 - 0.5 mm | 1.2 |
| Very fine to coarse | 0.0625 - 1 mm | 1.3 |
| Very fine to very coarse | 0.0625 - 2 mm | 1.4 |
| Fine to medium | 0.125 - 0.5 mm | 2.1 |
| Fine to coarse | 0.125 - 1 mm | 2.2 |
| Fine to very coarse | 0.125 - 2 mm | 2.3 |
| Medium to coarse | 0.25 - 1 mm | 3.1 |
| Medium to very coarse | 0.25 - 2 mm | 3.2 |
| Coarse to very coarse | 0.5 - 2 mm | 4.1 |

[217] The comparative material was consulted at the University of Tel Aviv Comparative Microarchaeology Laboratory with the kind assistance of Dr. Yuval Goren.

Fig. I.3: Power's Scale of Roundness

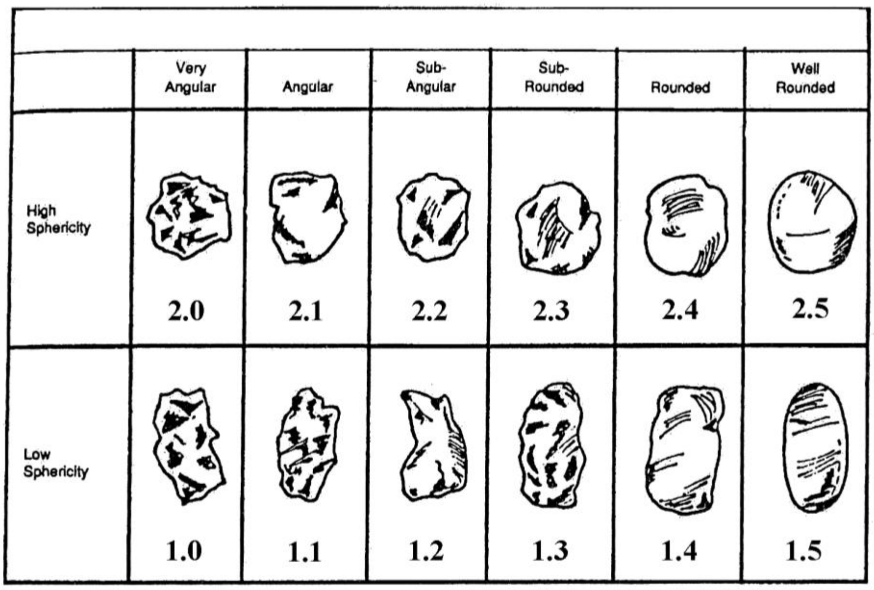
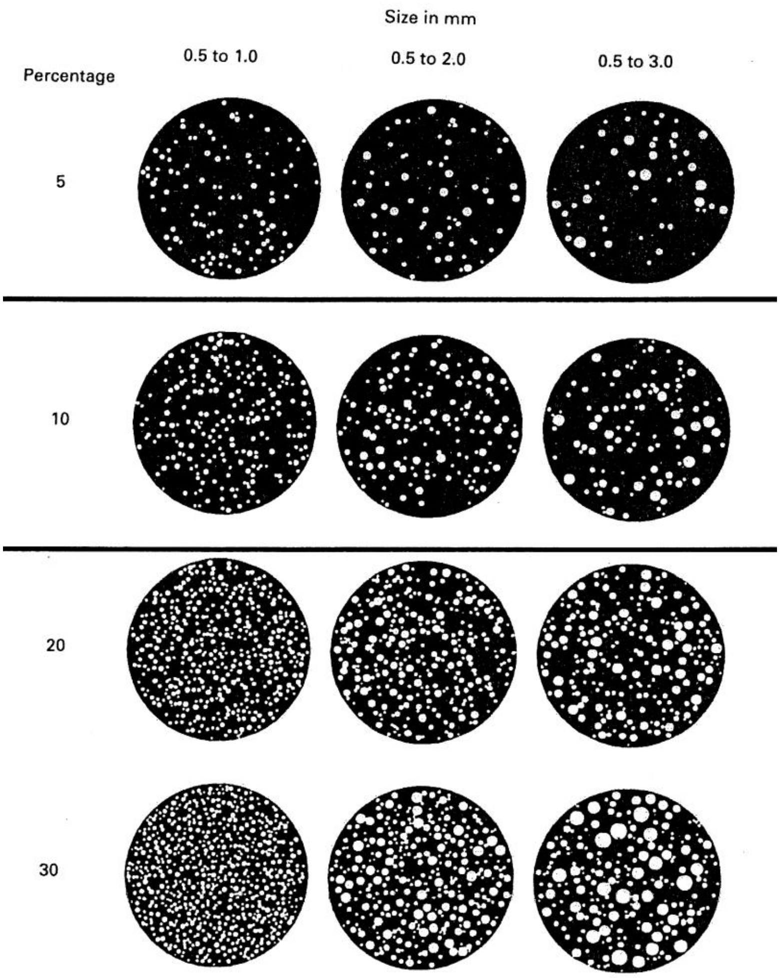



Fig. I.4: Chart for measuring percentage of inclusions



### III.3 Point-counting Procedures

Point counting each thin section is the method for producing quantitative data on the frequency of inclusions from ceramic thin sections[218]. A mechanical stage was attached to the Nikon Optiphot polarizing microscope. This stage is controlled by the Swift Model F point counting system, which moves the stage a set increment, in this case 3 mm, to the next point to be counted. Several ceramic petrographic studies have suggested that for samples with sizable inclusions, a large distance between the points is desirable to avoid counting the same inclusions repetitively and to gain a more representative sample (e.g. Middleton *et al*. 1985: 73). The intersection of the X-axis and Y-axis of the graticule in the microscope's eyepiece created the point to be counted. For our purposes, only inclusions (those above 0.0625 mm) and the matrix (clay and everything below 0.0625 mm) were counted while the voids or pores were skipped. During the point counting the magnification was set at 100x, but would be increased if it was difficult to tell where the cross hairs had landed or if determination of the inclusion type was problematic.

The twelve channels on the Swift Model F were designated for the most common inclusions, consisting of quartz, limestone, K-feldspars, plagioclase, polycrystalline quartz, chert, chalk, calcite, opaques, clay pellets, iron oxides, and matrix[219]. A total of 200 points was counted for each thin section (first set only), which was felt to provide the best estimate for inclusion frequency (see discussion in Chapter 4). In order to ensure the entire thin section was examined, transects were counted close to the edge of the thin section and within the middle. These transects were evenly spaced and their number depended on the size of the thin section. Potential sampling bias between the different sizes of the thin sections is negligible as the process is random in terms of where the cross hairs of the graticule land (Orton 2000: 186-187).

## *IV ICP Protocol*

### IV.1 Sample Preparation

Large pieces were cut from the sherds for chemical analysis. This was due to the sizable inclusions seen petrographically in most of the sherds and a concern for acquiring a representative sample for analysis (Bromund *et al*. 1976). The surfaces of the pieces were

[218] The selection of which method to use for point counting is discussed in Chapter 4.
[219] A form was developed to record the counts for these components along with twenty-one other inclusion types. An additional form recorded the beginning and end locations for the transects and the number of points counted during each transect.

ground off with the Buehler Motorpol 2000 grinder/polisher. This was to eliminate any surface post-depositional contamination so that the chemical analyses were only deriving from the core ceramic material (Franklin & Vitali 1985; Schwedt *et al*. 2004). Each sample was weighed before and after grinding (Table I.2). No other measures were taken to prepare the samples before powdering. However, for some compositional studies of pottery various procedures of washing and ignition have been implemented to remove perceived contaminates, water present in the sherd, and volatile materials such as organic remains (see Wilson 1978 for a review). These procedures were not employed in this study because they were not done for the NAA analysis (Al Dayel 1995: 63). For the ICP analysis, 40 sherds from the MBA Canaanite jars were selected, including six previously analyzed by NAA to assist in correlating the two data sets. For five of the sherds (Ownby 1, 5, 9, 13, and 20), two pieces were ground into a powder and analyzed separately in order to assess the homogeneity of the sherd.

Table I.2 : Sample List for ICP Analysis and Weights

| **Sample #** | **Sample Weight (before grinding)** | **Sample Weight (after grinding)** |
|---|---|---|
| Ownby 1A | 9.7 g | 8.1 g |
| Ownby 1B | 4.6 g | 3.6 g |
| Ownby 2 | 7.5 g | 6.1 g |
| Ownby 3 | 10.1 g | 8.4 g |
| Ownby 4 | 6.7 g | 5.9 g |
| Ownby 5A | 7.0 g | 6.1 g |
| Ownby 5B | 6.9 g | 5.6 g |
| Ownby 6 | 6.9 g | 5.2 g |
| Ownby 7 | 8.8 g | 7.2 g |
| Ownby 8 | 8.6 g | 6.7 g |
| Ownby 9A | 8.8 g | 7.6 g |
| Ownby 9B | 7.0 g | 5.7 g |
| Ownby 10 | 8.9 g | 7.0 g |
| Ownby 11 | 10.8 g | 8.6 g |
| Ownby 12 | 6.9 g | 5.6 g |
| Ownby 13A | 9.3 g | 8.6 g |
| Ownby 13B | 7.1 g | 5.9 g |
| Ownby 14 | 11.3 g | 7.3 g |
| Ownby 15 | 6.1 g | 3.8 g |
| Ownby 16 | 5.6 g | 4.4 g |
| Ownby 17 | 10.2 g | 9.0 g |
| Ownby 18 | 8.9 g | 7.2 g |
| Ownby 19 | 9.0 g | 7.1 g |
| Ownby 20A | 9.3 g | 7.2 g |

| Sample # | Sample Weight (before grinding) | Sample Weight (after grinding) |
|---|---|---|
| Ownby 20B | 8.1 g | 6.4 g |
| Ownby 21 | 8.6 g | 7.8 g |
| Ownby 22 | 9.0 g | 6.8 g |
| Ownby 23 | 14.3 g | 12.1 g |
| Ownby 24 | 10.2 g | 8.1 g |
| Ownby 25 | 8.9 g | 7.7 g |
| Ownby 26 | 3.4 g | 3.1 g |
| Ownby 27 | 2.4 g | 2.1 g |
| **Ownby 33** | 14.2 g | 11.8 g |
| **Ownby 35** | 6.9 g | 6.2 g |
| **Ownby 37** | 7.2 g | 6.1 g |
| **Ownby 42** | 8.1 g | 7.1 g |
| **Ownby 45** | 9.9 g | 8.1 g |
| **Ownby 49** | 14.2 g | 13.0 g |
| Ownby 50 | 5.3 g | 4.5 g |
| Ownby 51 | 9.3 g | 8.3 g |
| Ownby 52 | 7.5 g | 6.8 g |
| Ownby 53 | 7.1 g | 6.2 g |
| Ownby 54 | 6.9 g | 6.4 g |
| Ownby 55 | 6.6 g | 5.9 g |
| Ownby 56 | 8.2 g | 7.2 g |

* **Bold** samples have NAA data

## IV.2 Sample Dissolution

Powdering the samples and dissolving them for analysis was performed at the University of London Royal Holloway Department of Geology laboratory[220]. The individual sherd pieces were crushed using a metal hammer and anvil to break them into smaller pieces for milling. A swing mill was employed to reduce the crushed fragments of pottery into a powder. For digestion by lithium metaborate fusion, 0.2 grams of sample powder and 1g of lithium metaborate was placed in a small graphite crucible[221]. A blank of just lithium metaborate, five powdered internal standards for the laboratory, and one international standard ceramic powder (SARM 69) were also digested by this method and analyzed. This was to monitor the accuracy and precision of the instruments both within the laboratory and internationally. The graphite crucibles were then placed into a furnace set at 950°C for 25 minutes. The resulting molten sample was poured into individual polythene beakers filled

[220] Dr. Emma Tomlinson and Ms. Sue Hall kindly trained the author for preparing and analyzing the samples by ICP-AES at Royal Holloway and greatly assisted with the work.
[221] For samples Ownby 7, 17, and 49 two fusions were made from the same powder to assess the elemental variability within the sample powder.

with 200ml of 5% $HNO_3$ that were set on a magnetic stirrer. After 30 minutes, the beakers were removed from the magnetic stirrer and the liquid solution was poured into 10ml labelled specimen tubes. This procedure diluted the elemental concentrations from the solid samples by 1000 times for introduction into the ICP-AES. For analysis, five laboratory blanks were run to prepare the instrument. During analysis, a drift solution was run every eight samples. This allowed for correction of the drift in elemental values that naturally occurs between analyses while an instrument is running.

### IV.3 ICP-AES Instrumentation

Analysis was performed on a Perkin Elmer Optima 3300RL ICP-AES. The samples were introduced into the instrument with an AS91 auto-sampler using a peristaltic pump with a flow rate of 1.5 $Lmin^{-1}$. The liquid then entered the cross-flow nebulizer with an argon gas flow rate of 0.8 $Lmin^{-1}$ (Thompson & Walsh 1989: 8-9). The argon gas was used to create an aerosol mist that was injected into the Ryton Scott type spray chamber. This chamber allowed the heavier liquid particles to drop to the bottom for removal while the lighter particles were introduced into the torch assembly. The torch injected the mist at a very high speed upwards creating a hole in the plasma (this gives the toroidal or ring shape distinctive of the ICP). Three concentric tubes made up the quartz torch (Thompson & Walsh 1989: 10). The outer tube utilized an Ar plasma gas with a flow rate of 15 $Lmin^{-1}$ to form the plasma and cool the torch. The second tube contained an Ar gas with a 0.5 $Lmin^{-1}$ flow rate to prevent the plasma and liquid sample from interacting. The inner third tube received the argon gas and sample mist from the spray chamber.

The plasma was created through a process known as inductive coupling (Thompson & Walsh 1989: 10). This involved using a spark from a Tesla coil to ignite the Ar gas and initiate the removal of electrons from the atoms in the Ar gas. These loose electrons then removed the electrons from other argon atoms continuing the process and creating a plasma with a temperature of up to approximately 10,000K. The argon plasma was maintained by a 40 Hz radio frequency generated from a copper load/induction coil around the torch. By applying an AC current of 1.3 kW to the coil, an oscillating magnetic field is created which maintains the plasma’s axis (Thompson & Walsh 1989: 9-10). The radio frequency field also promoted the continued collision of electrons with the Ar atoms. When the sample interacts with the plasma, the solvent is first removed before the particles are vaporized into their separate molecules and then broken down into individual atoms. The high temperature excites the sample atoms so that they emit characteristic light.

Concave mirrors focused the light emitted by the atoms and directed it toward the spectrometer through a radial view entrance slit (Thompson & Walsh 1989: 48). An Echelle grating-based polychromator utilized a diffraction grating to separate the light based on wavelength and a prism perpendicular to the grating further divided the multiple overlapping spectral orders (Thompson & Walsh 1989: 52). This two dimensional pattern, called an echellogram, has the wavelengths on one axis and the spectral orders on the other. Using the high spectral orders and not just a single specific order, gives the spectrometer an increased resolution. Another concave mirror directed the separated wavelengths to the Segmented-array Charge-coupled device Detector (SCD). This detector covered approximately 6000 wavelengths through its 235 discrete subarrays on a 13 x 19 mm silicon substrate. Each subarray had between 20 and 80 photosensitive pixels that identified electronically the specific wavelengths while also gathering a charge indicative of the amount of light it received. A photomultiplier converts the light detected into an output voltage signal comprised of which pixels were activated by the atomic specific wavelengths and the level of activation as indicative of the amount of atoms with this wavelength in the sample (Thompson & Walsh 1989: 12). Based on a comparison of light intensity for samples of known elemental concentration, the amount of each element in the sample was determined.

The voltage signal was fed into a computer that utilized the Winlab32 software for data collection and control of the instrument. The instrument was set to do three replicates with a read time set on auto (0.5 seconds). For the interpretation of the incoming data from the spectrometer, a normal resolution was used with all of the peak height for the elements and none of the peak area. Upon examination of the initial data and the movement of the elemental peaks, it was noticed that the values were varying slightly due to instrumental drift. Therefore, 2ml of the fusion solution for each sample and the standards was taken and doped with gallium for a second analysis by ICP-AES[222]. The gallium provided an internal correction for each sample and improved the results of the data[223]. The mean values of the three replicates were taken for each sample and utilized as representative of the elemental concentrations for the samples.

[222] The initial lithium fusions did not contain gallium as the ICP-MS could not analyze solutions with this element.

[223] I am grateful to Dr. Emma Tomlinson for taking the time to examine the initial data and run the second set doped with gallium.

### IV.4 ICP-MS Instrumentation

The remaining 6ml of the fusion sample solution was taken for ICP-MS analysis at the School of Earth Sciences and Geology at Kingston University[224]. The greater sensitivity of the ICP-MS, detection limits of parts per billion (ppb), necessitated a further dilution of the sample fusions. For each sample, 0.4ml was taken with a pipette and transferred to a 10ml test tube. To these tubes was added 9.4ml of filtered water and 0.2ml of 5% $HNO_3$. This resulted in a further dilution of 25 times and a total dilution of 25,000 from the solid sherd sample. For the analysis, one laboratory blank standard, the blank of the lithium metaborate, and four elemental standards were initially run to set up the instrument. A drift sample was run every fifth analysis to correct for the normal analytical variation that occurs during instrument operation.

An Agilent 7500 Series ICP-MS with Octopole Reaction System was utilized for the analysis. The front end of this instrument with the ICP system is virtually identical to the ICP-AES. However, an auto-sampler was not attached to this instrument and the tube that introduced the liquid fusion into the nebulizer was moved by hand from sample to sample. A peristaltic pump with a flow rate of 0.15 rps moved the liquid along the tubing. The cross-flow nebulizer had an Ar gas flow rate of 0.8 $Lmin^{-1}$. The spray chamber was a Quartz Scott-type and the quartz torch featured three concentric tubes set up in the same manner as on the ICP-AES. For the ICP-MS, the Ar plasma gas in the outer tube had a flow rate of 15 $Lmin^{-1}$ and the Ar gas in the second tube had a flow rate of 0.4 $Lmin^{-1}$. The plasma itself was made utilizing a spark from a Tesla coil and the same process as in the ICP-AES. However, the radio frequency generator that maintained the Ar plasma used a 27-mega Hz frequency and operated on 1.5 kW. With this set up, not only was the sample atomized, but also ions were formed by the removal of electrons from the atoms.

For this instrument, both sampling and skimmer cones were employed to direct the gas containing the ions from the plasma and bring them into the mass spectrometer, which is held at high vacuum (Jarvis *et al*. 1992: 78-80, 51). The vacuum setting for the interface between the plasma and mass spectrometer was 309 Pa, for the area containing the ion lenses it was 324 Pa, and for the analyzer it was $2.25 \times 10^{-4}$ Pa. An ion beam was created from the loose ions by channelling them through several negatively charged plates called ion lenses (Jarvis *et al*. 1992: 31-35). The ion beam then flowed through a quadrupole mass filter consisting of four stainless steel rods, two that were positively charged and two that were

[224] The ICP-MS work was facilitated by Dr. Benoit Disch and Dr. Kym Jarvis at Kingston.

negatively charged (Jarvis *et al*. 1992: 37). A steady voltage of 200 V and an oscillating radio frequency of 3-mega Hz were passed through the rods in order to create a beam of ions with a particular mass to charge ratio, while the remaining ions were deflected (Jarvis *et al*. 1992: 38). The voltages passing through the rods were changed very rapidly to select sequentially ions with mass units between 0 and 800 (Jarvis *et al*. 1992: 44). This enabled the instrument to scan through all of the available ions for the detector to identify.

The ion detector featured a dynode Channeltron electron multiplier to acquire the ions with the specified mass to charge ratio (Jarvis *et al*. 1992: 48-50). The ions were attracted to the negative potential at one end of the electron multiplier, and upon hitting this surface they emitted secondary electrons. Within the electron multiplier, the secondary electrons were multiplied when they bombard each other. This created a single pulse at the collector. The analog pulse was converted to a digital pulse and then counted by the microprocessor within the computer (Skoog *et al*. 1998: 80-83). The attached computer utilized calibration standards of known elements and concentrations to determine the element represented by the pulse and its magnitude (Jarvis *et al*. 1992: 50). The magnitude of the current of ions was proportional to the amount of ions sent to the detector (Pollard & Heron 1996: 63). In this way, the detector was able to determine the concentration of the individual elements identified. Acquisition time for determining the elements and their concentration was 22.86 seconds.

ChemStation software processed the data and controlled the ICP-MS. For each sample, three replicates were run during the 31 seconds of sampling time. Once again, the elemental values from the three replicates was averaged and employed as the elemental concentration values for the samples. Since the data were given as ppb all of the values had to be multiplied by 25 (the amount of dilution for the ICP-MS) to acquire the ppm values. This was necessary since the ICP-AES data for the minor elements was reported in ppm.

## *V Statistical Analysis Protocol*

### V.1 Preparation of Raw Data

The raw data produced from the instrumental analyses were modified in several ways to compensate for fluctuations in the instrument's acquisition and analysis of the solution, and to account for background or spurious signals present during any instrumental analysis. The drift samples that were run every eighth analysis for the ICP-AES data were examined to determine the instrumental variability and the spectral lines for the elements were adjusted based on this information. Secondly, all instruments have a limit to which they can detect elemental concentrations, called the limit of detection (LOD) (Skoog *et al*. 1998: 13). This limit was determined by repeat analysis of the blank sample (comprised of only lithium metaborate) and calculating the mean plus three times the standard deviations from the resulting data. The slope from this equation is used as the value for the LOD, which represents the amount that the analytical signal must be larger than in order to be confident the analysis correctly determined the elemental concentration. Multiplying the standard deviation by three gives a 95% confidence for the level of detection. Finally, the limit of quantitation (LOQ) was also established based on the repeat analysis of the blank (Skoog *et al*. 1998: 14). LOQ was calculated as 6 times the standard deviation plus the mean and represented the lowest concentration of an element for which the instrument could provide quantitative data. These values were used to recalculate the sample elemental concentration data to ensure they correctly reflected the limits of the instrumentation. The resulting data comprised the raw data for statistical analysis.

### V.2 Statistical Methods to Determine Precision and Accuracy

All compositional data are affected by both instrumental and random errors (Skoog *et al*. 1998: A-2, A-4). Because of this, the accuracy and precision of the analyses must be assessed to ensure the data is of the quality needed for the study. The accuracy of a technique refers to its ability to acquire elemental values that are very close to the "true" value of that element within the sample (Skoog *et al*. 1998: A-1, A-5). In order to assess instrumental accuracy, standard reference materials of known composition were prepared in an identical way to the samples and analyzed. For the ICP-AES analysis, these standards consisted of five internal laboratory powdered rock samples and one international ceramic standard, SARM 69. Internal laboratory standards were not used during the ICP-MS analysis; however, the SARM 69 sample was analyzed[225]. The resulting elemental concentrations were compared to the established values for these materials. The absolute error was calculated by subtracting the known value from the measured value. The relative error was calculated by dividing the absolute error by the known value and multiplying by 100 to give a percentage of error (Skoog *et al*. 1998: A-2). A percentage of error above 10% is acknowledged as indicating results that may prove unreliable for later statistical analysis.

To investigate the precision of the data several descriptive statistics were calculated for the concentration values. Instrumental precision concerns the instrument's ability to

[225] The certificate of analysis with the determined elemental values for the SARM 69 certified reference material was acquired from the manufacture's website, www.mintek.co.za

acquire the same or very similar elemental values over repeat analyses (Skoog *et al*. 1998: A-1). In general, background noise, slight changes in the operation of the instrument, and even variability in sample preparation can all lead to slightly different elemental values for the same sample. To examine the variability between analyses the standard deviation (SD), and relative standard deviation (RSD) were determined individually for each sample (Skoog *et al*. 1998: A-6, A-7). The SD is the square root of the individual deviations from the mean for all of the numbers. The RSD is the SD divided by the mean and multiplied by 100 to give a percentage. Typically, the RSD for ICP data should be within an acceptable range of between 1% and 3%.

### V.3 Preparation of Data for Statistical Analyses

To combine the ICP and NAA data the results from the six samples with data from both techniques was utilized[226]. First, graphs were made for each element with the NAA data on the Y-axis and the ICP data on the X-axis (Fig. I.5). This was done for those elements in common between the two data sets, namely Al, Ca, Ce, Co, Cr, Cs, Dy, Eu, Fe, Hf, K, La, Lu, Mn, Na, Rb, Sc, Sm, Ta, Th, Ti, U, V, and Yb. The six sample points were plotted on the graph and a trend line was run through them with the intercept set at zero. This trend line, actually a best-fit regression line based on the least-squares method, shows the line that is closest to all of the points and gives the linear equation between the data sets, y=a+bx (Shennan 1997: 131-139). The slope of the linear equation (b) was used to transform the ICP data to be more similar to the NAA data[227]. This was done by taking the ICP values (x) and multiplying by the slope to give the corresponding NAA value (y). All the ICP data was adjusted in this way to give values that are more similar to the NAA data. Finally, the $R^2$ value was calculated to assess the degree of similarity between the data, with values close to +1 or -1 being indicative of data sets with a high degree of comparability (Table I.3)[228]. This allowed elements with good correlation between the ICP and NAA to be identified, in this case Ca, Eu, Hf, La, Na, Sm, and Th.

Before statistical analysis, the data were transformed into base 10 logarithms. This method of data transformation has been suggested by several researchers as the most appropriate method for preparing data for statistical analyses (Bishop & Neff 1989: 63, 72; Baxter 2003: 75). Base 10 logarithms are used to put all of the data on the same scale, as the

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[226] Dr. Mike Hughes personally showed the author how to combine the data sets and provided invaluable advice and assistance.

[227] Since the intercept was set at zero, the equation then becomes y=bx, showing how multiplying a known x value by the slope will produce the corresponding y value.

[228] The value r is a correlation coefficient, with $R^2$ known as the coefficient of determination, which is a better indicator of the degree of correlation (Shennan 1997: 139-144).

major elements are report in wt% while the minor and trace elements are given in ppm, and to ensure the variances are roughly equivalent.

Fig. I.5: Graph of concentration of Cr from the six samples with NAA and ICP data

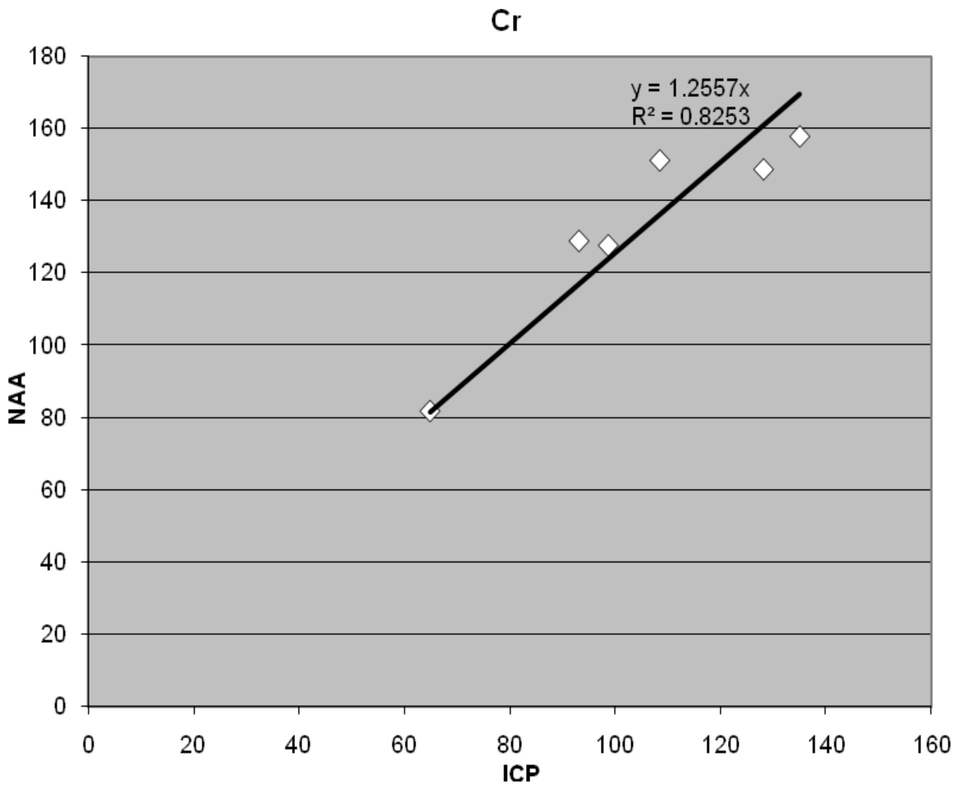



Table I.3: Coefficient of determination values for the ICP and NAA data graphs

| Element | $R^2$ value |
|---|---|
| Al | 0.59 |
| Ca | 0.94 |
| Ce | 0.84 |
| Co | -1.4 |
| Cr | 0.82 |
| Cs | 0.2 |
| Dy | 0.34 |
| Eu | -1 |
| Fe | 0.06 |
| Hf | 0.96 |
| K | -0.4 |
| La | 0.9 |
| Lu | -0.46 |
| Mn | -0.7 |
| Na | 0.89 |
| Rb | 0.35 |

| Element | $R^2$ value |
| --- | --- |
| Sc | -0.23 |
| Sm | 0.89 |
| Ta | -0.58 |
| Th | 0.93 |
| Ti | -0.55 |
| U | -3.25 |
| V | 0.3 |
| Yb | 0.71 |

### V.4 Statistical Test Parameters

The statistical analyses run in SPSS (Statistical Package for the Social Sciences) began with principal components analysis (PCA). This test allowed the variability within the data to be used to see if certain samples grouped together and to determine which elements accounted for most of this variability (Shennan 1997: 269-287; Baxter 2003: 73-83). In SPSS, this type of statistical test is called Factor Analysis, but the extraction method was specified as principal components. All of the elemental variables[229] were employed to create a correlation matrix that was used for the analysis. The resulting principal components were used to create three-dimensional scatter plots with no rotation to visualize the results.

Hierarchical cluster analysis (HCA) was performed to examine the relationships between the samples, identify outliers, and assess the quality of the data (Shennan 1997: 235-244; Baxter 2003: 92-99). The latter was determined by the samples that had been analyzed twice in which the results were grouped together. Ward's method was used to cluster the cases without cluster membership being assigned. The intervals between the cases were measured by the squared Euclidean distance. Dendrograms were created to show how the samples clustered together.

The next statistical test was discriminant analysis to examine how the data would group based on the petrographic information (Shennan 1997: 350-352; Baxter 2003: 105-111)[230]. For this analysis, the independents were entered together as for some tests entering the independents in a stepwise fashion did not provide any results. This is likely due to the importance of the interaction between the elements for the data. The prior probabilities were set to assume that all of the groups were equal. The classification utilized the within groups

[229]Often the statistical analyses were repeated with certain elements removed, usually those with poor accuracy and precision, and some samples eliminated to improve the results, see Chapter 5.
[230] This type of statistical test was also run with the samples assigned to their fabric group, both the Memphite in-field classification and the laboratory classification. In general the samples did not appear group well according to their fabric assignment.

correlation matrix.  The test produced a graph showing the assignment of samples to several groups.  Particularly for discriminant analysis, removing very different samples allows the other groups to be less tightly clustered since the test no longer needs to represent a group with a highly dissimilar composition (Bishop *et al*. 1982: 298, 306-307; Baxter 2003: 123).

The last statistical test was K-means cluster analysis (Shennan 1997: 250-251).  This test requires the number of clusters to be specified and aims to optimize the clustering of the data.  The parameters set specified that the analysis classify and iterate with a maximum of 10 iterations (this proved sufficient for all of the runs).  Initial cluster centres were used for the iterations.  The number of clusters was based on the number of petrographic groups.

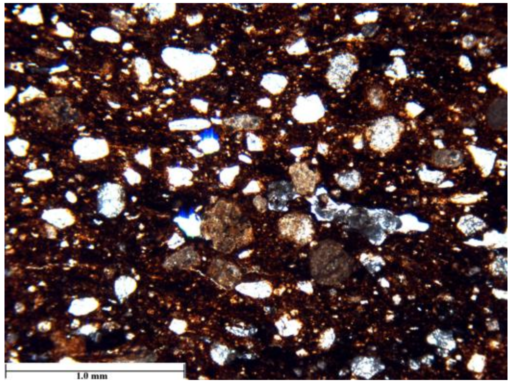
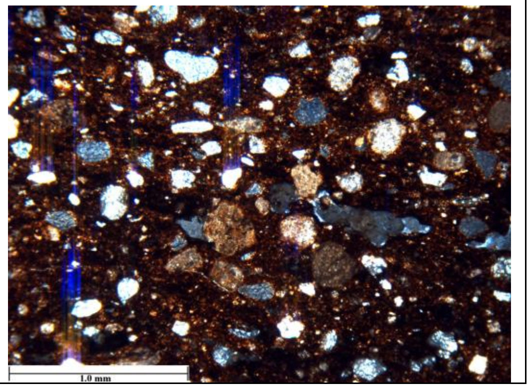
# Appendix II: Fabric and Petrographic Descriptions of Samples

Notes:

- For the Fabric Description, the abbreviations represent F=fine, M=medium, C=coarse, and VC=very coarse (see Appendix I, section I.3 for size ranges); the numbers in parentheses for the inclusions represent their frequency, 3=dominant, 2=common, 1=rare
- For the Petrographic Description the list of inclusion abbreviations can be found in Table II.1; (s)=the inclusion type is found in the silt; see Appendix I, Fig. I.4 for percentage of inclusions, Table I.1 for size ranges, Fig. I.3 for shape codes, and section III.2 frequency of inclusions; only the majority size and the dominant shape of the inclusions is given; Q/Feld= quartz/feldspar; Lim=limestone; Ch=chert
- For the Provenance description, provenances are all suggested; firing conditions are described generally as the temperature and atmosphere were probably variable and inconsistent
- Images are arranged as a microscopic image of the chip at 10x magnification (scale bar=1 mm), photomicrograph of thin section in plane polarized light (PPL) and cross polarized light (XPL) at 40x magnification (scale bar=1 mm)

Table II.1: Abbreviations for mineralogical inclusions

| **Abbreviation** | **Mineral** | **Abbreviation** | **Mineral** | **Abbreviation** | **Mineral** |
|---|---|---|---|---|---|
| QTZ | Quartz | MF | Microfossil | OLV | Olivine |
| QIT | Polycrystalline quartz | SH | Shell | PY | Pyroxene |
| KF | Potassium feldspar | FOX | Iron oxide | RUT | Rutile |
| PLAG | Plagioclase feldspar | OP | Opaque | SP | Serpentine |
| MIC | Mica (muscovite/biotite) | CP | Clay pellet | KYN | Kyanite |
| VRF | Volcanic rock fragment | AMP | Amphibole | SIL | Sillmanite |
| VGL | Volcanic glass | CHA | Chalcedony | STA | Staurolite |
| LIM | Limestone (micritc/sparry) | CHRAD | Radiolarian chert | TOR | Tourmaline |
| CAL | Calcite | CHREP | Replacement chert | OPL | Organic plant |
| KUK | Kurkar | EPI | Epidote | | |

| *Sample* | *Fabric Description* | *Petrographic Description* | *Provenance* | *Images* |
|---|---|---|---|---|
| Ow 1 | **Inclusions:** sand (F2, M1), plant remains (F1), limestone (F2, M1), subrounded grey-white particles (M1), chalk (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** crumbly<br>**Wall Thickness:** 9 mm<br>**Surface Colour:** exterior burnt black; interior 7.5YR5/2 (brown)<br>**Break Colour:** core 5YR2/1 (black); outer zones 5YR4/3 (reddish brown) | **Inclusions:** QTZ(s), QIT, KF, PLAG, LIM(s), CAL, MF, FOX(s), OP(s), CP, CHREP, EPI(s), PY, SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.1; Q/Feld 1.2; Lim 1.3; Ch 2.1<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch rare<br>**Colour PPL:** light to dark brown<br>**Colour XPL:** light to dark brown<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** quartz, bioclasts, some limestone and chert<br>**Firing:** reduce fired between 700°C and 800°C<br>**Provenance:** Northern Coastal Palestine<br>**Comments:** similar proportion of quartz and bioclasts suggests the northern coast of Palestine | <br><br> |

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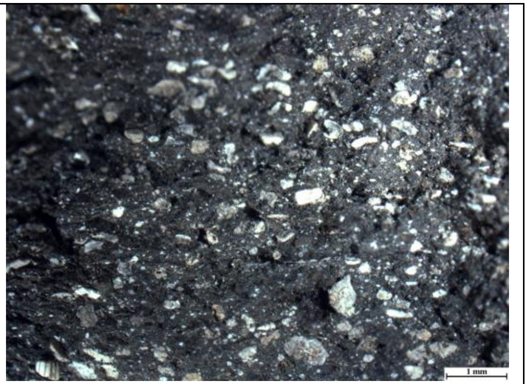
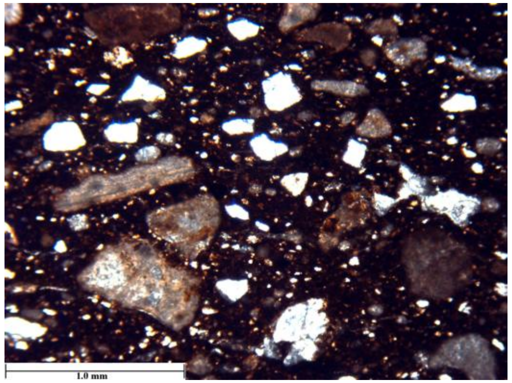
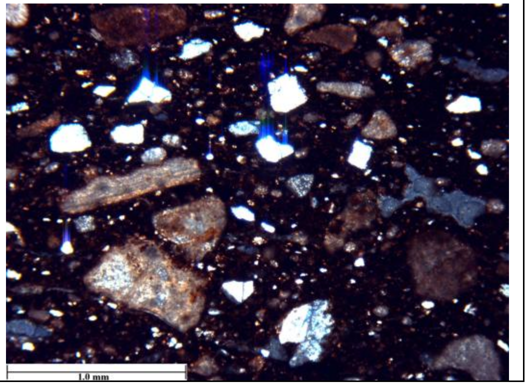
| Ow 2 | **Inclusions:** sand (F1), plant remains (F1), limestone (F2, M1), subrounded grey-white particles (M1), shell strips (M1), microfossils (M1), chalk (VC1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** crumbly<br>**Wall Thickness:** 6 mm<br>**Surface Colour:** exterior missing; interior 7.5YR6/6 (reddish-yellow)<br>**Break Colour:** no zones, 7.5YR4/0 (dark grey) | **Inclusions:** QTZ(s), QIT, KF, LIM, CAL(s), MF, FOX(s), OP(s), CP, CHREP, EPI(s), PY(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 20-30%<br>**Grain Size Range:** 2.2; Q/Feld 1.2; Lim 1.4; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim abundant; Ch sparse<br>**Colour PPL:** dark brown, one edge is medium tan<br>**Colour XPL:** dark brown, one edge is medium tan<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** reduce fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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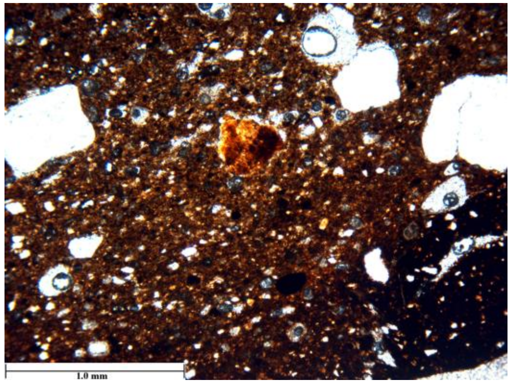
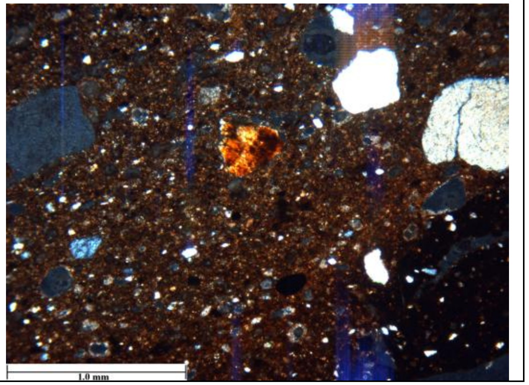
| Ow 3 | **Inclusions:** sand (F1, M2, C1), limestone (F1, M1), microfossils (F2), black rock particles (M1), chalk (VC1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** crumbly<br>**Wall Thickness:** 5 mm<br>**Surface Colour:** exterior 7.5YR5/4 (brown); interior missing<br>**Break Colour:** core 7.5YR4/0 (dark grey); outer zones 7.5YR5/2 (brown) | **Inclusions:** QTZ(s), QIT, KF, PLG, LIM, CAL(s), MF, FOX(s), OP(s), CP, CHA, CHREP, EPI(s), PY(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 5%<br>**Grain Size Range:** 1.2; Q/Feld 1.3; Lim 1.3; Ch 3.1<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld sparse; Lim sparse; Ch very rare<br>**Colour PPL:** dark brown to medium brown<br>**Colour XPL:** dark to medium reddish brown on edge<br>**Optical Activity:** slightly active | **Clay Type:** rendzina and *Terra Rossa*<br>**Inclusions:** bioclasts and limestone, some silty and mature quartz<br>**Firing:** reduced fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** presence of mature quartz and bioclasts suggests coast of Lebanon | <br><br> |

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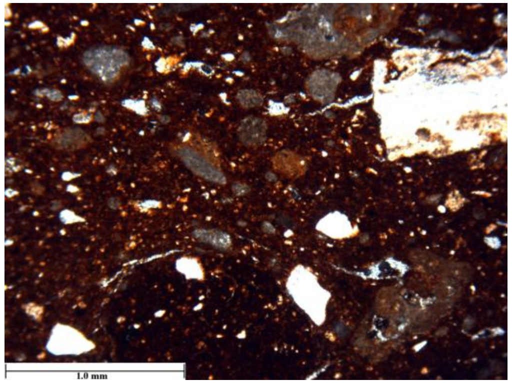
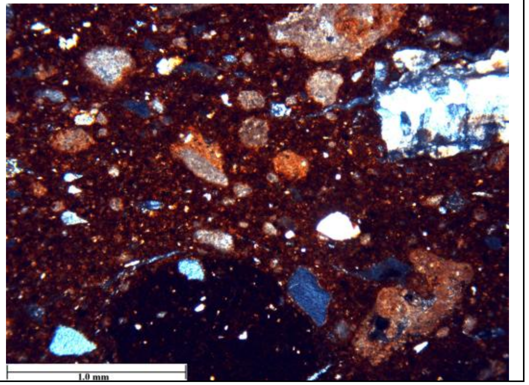
| Ow 4 | **Inclusions:** sand (F2, M2, C1), plant remains (C1), limestone (F2, M2, C1), chalk (VC1, C2, M1), black rock particles (C1, M1, F1)<br>**Sorting:** poor<br>**Porosity:** medium<br>**Hardness:** crumbly<br>**Wall Thickness:** 5 mm<br>**Surface Colour:** exterior burnt; interior 7.5YR4/2 (brown)<br>**Break Colour:** no zones, 7.5YR4/2 (brown) | **Inclusions:** QTZ(s), QIT, PLG, LIM, CAL(s), FOX(s), OP(s), CP, CHA, CHREP, EPI(s), PY(s), RUT(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.3; Q/Feld 1.3; Lim 1.3; Ch 2.3<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch sparse<br>**Colour PPL:** medium red-brown, thin medium brown on one edge<br>**Colour XPL:** dark red-brown, thin dark brown on one edge<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** iron-stained chalk, limestone, chert<br>**Firing:** slightly reduce fired between 700°C and 800°C<br>**Provenance:** Inland Lebanon<br>**Comments:** sedimentary inclusions and lack of coastal sand suggest slightly inland Lebanon | <br><br> |

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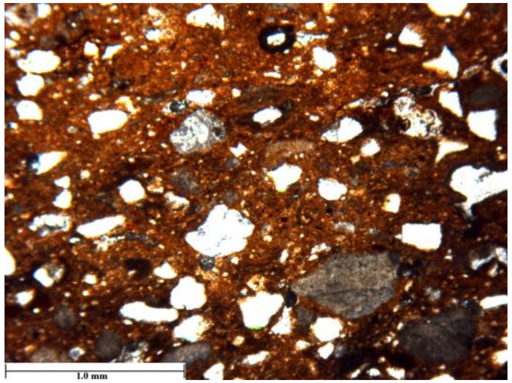
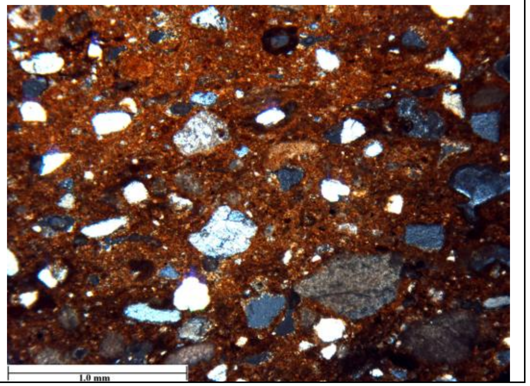
| Ow 5 | **Inclusions:** sand (F2, M1), plant remains (F1), limestone (F1, M1, C1), grey-white particles (VC1, F1), black rock particles (M1, F1), unmixed clay (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 10 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow) with combing; interior missing<br>**Break Colour:** core 5YR5/1 (grey); outer zones 5YR6/8 (reddish-yellow) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM, CAL(s), MF, FOX(s), OP(s), CP, CHREP, EPI(s), OLV, PY(s), SP(s), KYA, STA, OPL<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.3; Q/Feld 1.2; Lim 1.4; Ch 2.1<br>**Grain Shape Range:** Q/Feld 1.4, 2.4; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim sparse; Ch rare<br>**Colour PPL:** medium to dark red-brown<br>**Colour XPL:** medium to dark red-brown<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** quartz, bioclasts, some limestone and chert<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Northern Coastal Palestine<br>**Comments:** similar proportion of quartz and bioclasts suggests the northern coast of Palestine | <br><br> |

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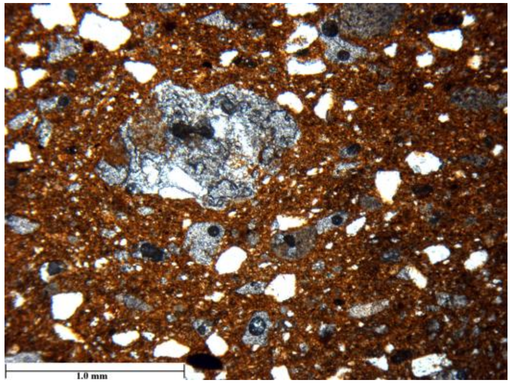
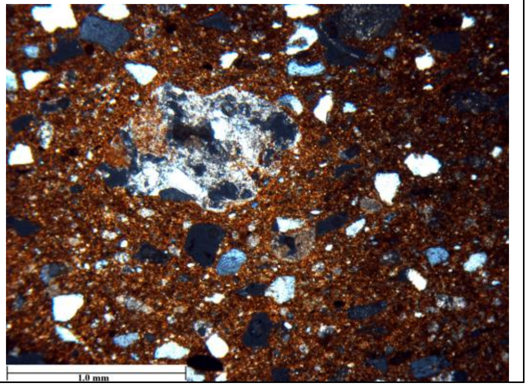
| Ow 6 | **Inclusions:** sand (F2, M2, C1), limestone (F2, M1), red-brown rock particles (M1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 7.5YR7/4 (pink); interior 5YR6/6 (reddish yellow)<br>**Break Colour:** no zones, 5YR6/8 (reddish yellow) | **Inclusions:** QTZ(s), QIT, KF, PLG, LIM(s), CAL(s), MF, FOX(s), OP(s), CP, CHREP, EPI(s), OLV(s), PY, SP(s), KYA, OPL(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.3; Q/Feld 1.2; Lim 1.4; Ch 2.2<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim sparse; Ch rare<br>**Colour PPL:** light to medium red-brown, light yellow-brown on one side<br>**Colour XPL:** dark red-brown to tan, reddish brown core<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** quartz, bioclasts, some limestone and chert<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Northern Coastal Palestine<br>**Comments:** similar proportion of quartz and bioclasts suggests the northern coast of Palestine |    |

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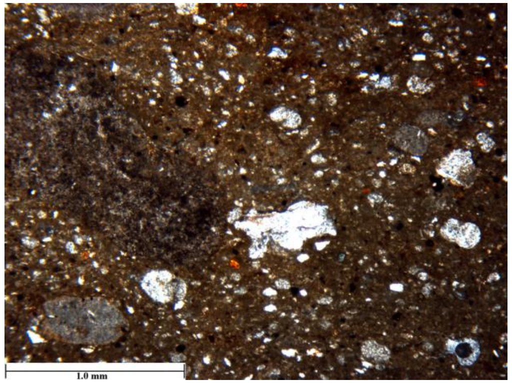
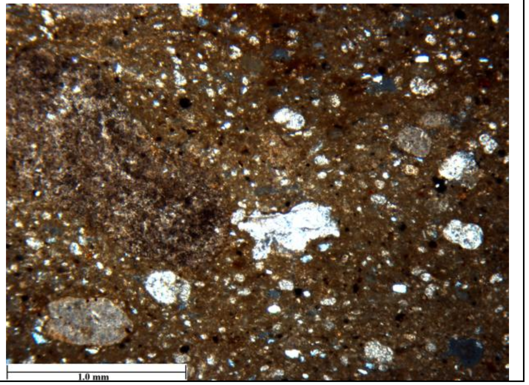
| Ow 7 | **Inclusions:** sand (F2, M1, C2), black rock particles (C1), shale (VC1)<br>**Sorting:** poor<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 11 mm<br>**Surface Colour:** exterior 10YR7/4 (very pale brown) with combing; interior 10YR8/4 (very pale brown)<br>**Break Colour:** no zones, 10YR7/4 (very pale brown) | **Inclusions:** QTZ(s), PLG, LIM, CAL, MF, SH, FOX, OP, CP, AM, CHREP, PY, SP, OAN<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.1; Lim 1.4; Ch 2.0<br>**Grain Shape Range:** Q/Feld 1.3, 2.4; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld sparse; Lim abundant; Ch very rare<br>**Colour PPL:** medium brown/gray with dark brown patches<br>**Colour XPL:** medium brown/gray with dark brown patches<br>**Optical Activity:** slightly active | **Clay Type:** foramin-aferous marl and *Terra Rossa*<br>**Inclusions:** limestone with little quartz or chert<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Inland Levant<br>**Comments:** generalized sedimentary inclusions widespread in the Levant, but no coastal material | <br><br> |

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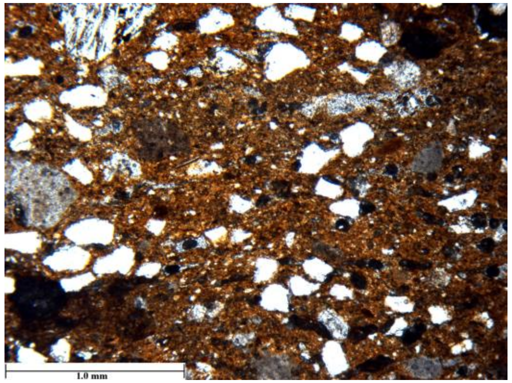
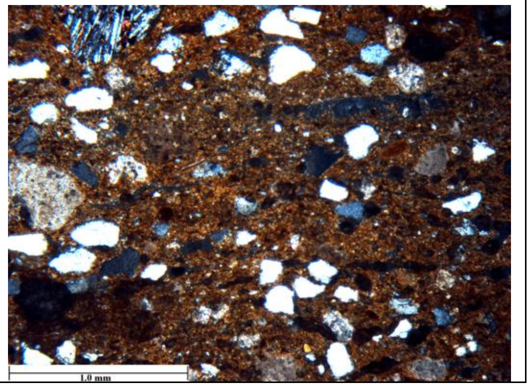
| Ow 8 | **Inclusions:** sand (F2, M2, C1), plant remains (C1), limestone (F1), black rock particles (F1), red-brown rock particles (M1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 5YR6/6 (reddish yellow)<br>**Break Colour:** no zones, 5YR6/6 (reddish yellow) | **Inclusions:** QTZ(s), QIT, KF, PLG, VRF, LIM, CAL, MF, FOX, OP, CP, CHREP, EPI, PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 2.1; Q/Feld 1.2; Lim 1.4; Ch 2.0<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim sparse; Ch rare<br>**Colour PPL:** light red-brown<br>**Colour XPL:** medium red-brown<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** quartz, bioclasts, some limestone and chert, basalt fragment<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Northern Coastal Palestine<br>**Comments:** similar proportion of quartz and bioclasts suggests the northern coast of Palestine, basalt probably from Carmel Ridge |    |

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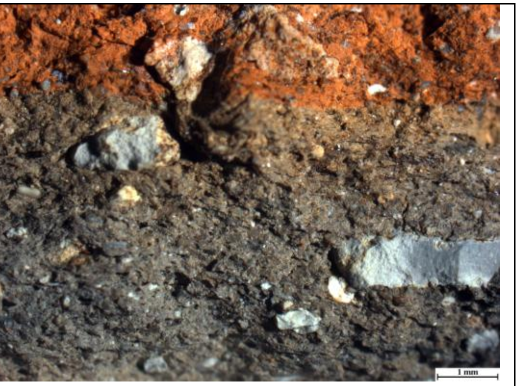
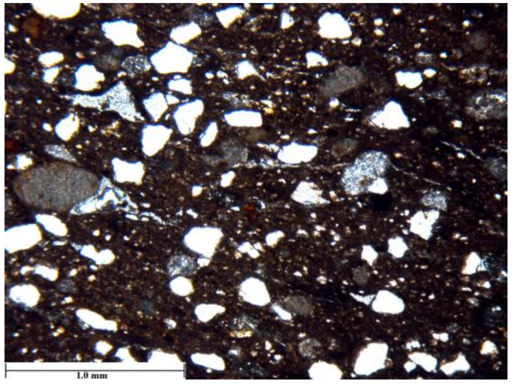
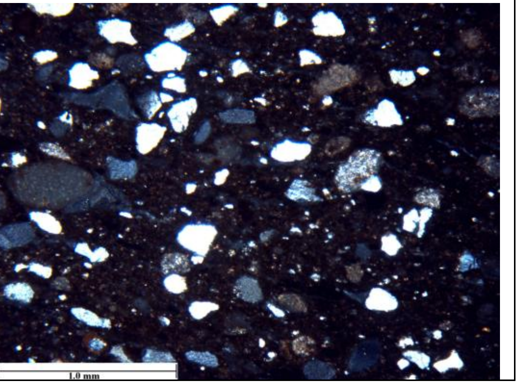
| Ow 9 | **Inclusions:** sand (F3, M1, C1), limestone (F1, M1, C1), chalk (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior missing<br>**Break Colour:** core 7.5YR5/2 (brown); outer zones 5YR5/8 (yellowish red) | **Inclusions:** QTZ(s), QIT, KF, PLG(s), MIC, LIM, CAL(s), MF, FOX(s), OP(s), CP, CHREP, EPI(s), PY, SP, KYA, OPL<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 2.1; Q/Feld 1.3; Lim 1.4; Ch 2.1<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim sparse; Ch rare<br>**Colour PPL:** dark brown middle, one side dark red-brown, the other side medium red-brown<br>**Colour XPL:** dark brown middle, one side dark red-brown, the other medium red-brown<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** quartz, bioclasts, some limestone and chert<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Northern Coastal Palestine<br>**Comments:** similar proportion of quartz and bioclasts suggests the northern coast of Palestine | <br><br> |

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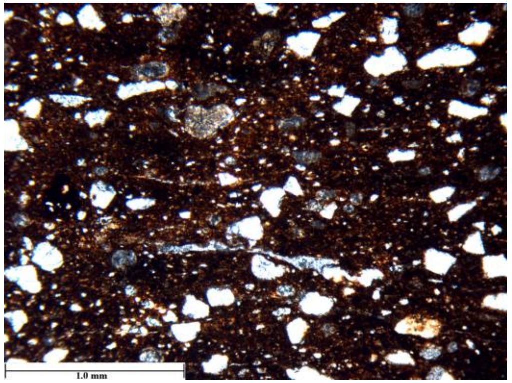
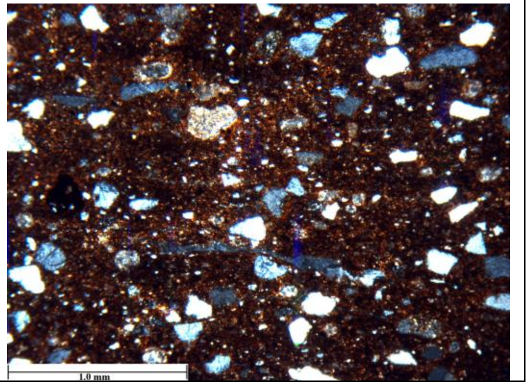
| Ow 10 | **Inclusions:** sand (F2), limestone (F2, M1, C1), black rock particles (F1), shale (M1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 9 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 5YR4/1 (dark gray)<br>**Break Colour:** no zones, 5YR4/1 (dark gray) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM, CAL(s), MF, FOX(s), OP(s), CP, CHREP, EPI(s), PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 2.1; Q/Feld 1.2; Lim 1.4; Ch 2.1<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim sparse; Ch rare<br>**Colour PPL:** medium to dark red-brown, edges lighter<br>**Colour XPL:** medium red-brown, tan around edges<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** quartz, bioclasts, some limestone and chert<br>**Firing:** reduced fired between 700°C and 800°C<br>**Provenance:** Northern Coastal Palestine<br>**Comments:** similar proportion of quartz and bioclasts suggests the northern coast of Palestine | <br><br> |

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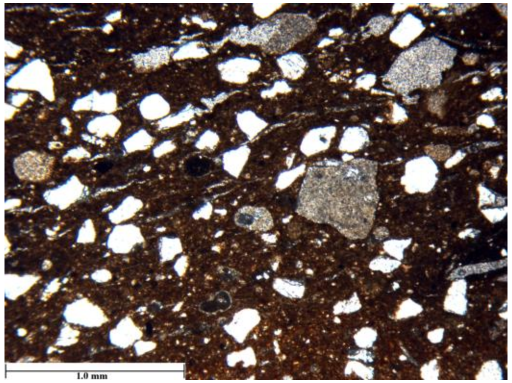
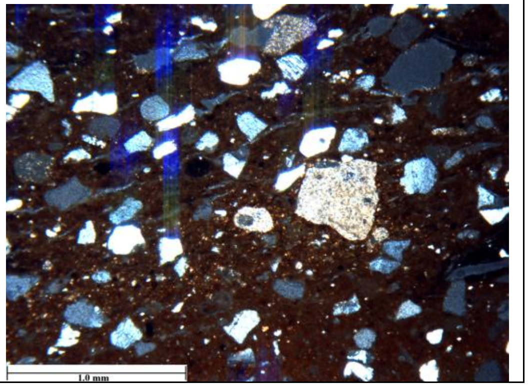
| Ow 11 | **Inclusions:** sand (F2), plant remains (F1), limestone (F1, M1, C1), black rock particles (F1, C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** crumbly<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 2.5YR6/6 (light red) with combing; interior 7.5YR6/3 (light brown)<br>**Break Colour:** no zones, 7.5YR5/1 (gray) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM, CAL(s), FOX(s), OP(s), CP, AM(s), CHREP, EPI(s), OLV, PY(s), KYA<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 2.1; Q/Feld 1.2; Lim 1.4; Ch 2.1<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim sparse; Ch rare<br>**Colour PPL:** dark brown, red-brown on one edge<br>**Colour XPL:** very dark brown, dark red-brown on one edge<br>**Optical Activity:** slightly active | **Clay Type:** *Hamra*<br>**Inclusions:** quartz, bioclasts, some limestone and chert<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Northern Coastal Palestine<br>**Comments:** similar proportion of quartz and bioclasts suggests the northern coast of Palestine |    |

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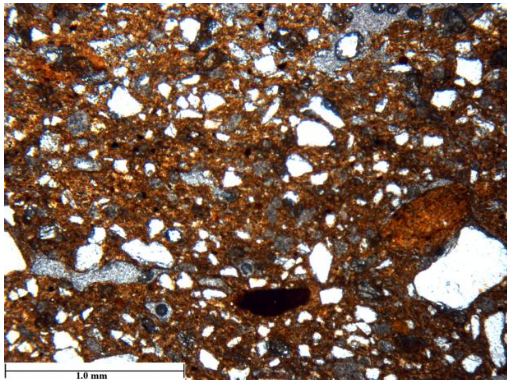
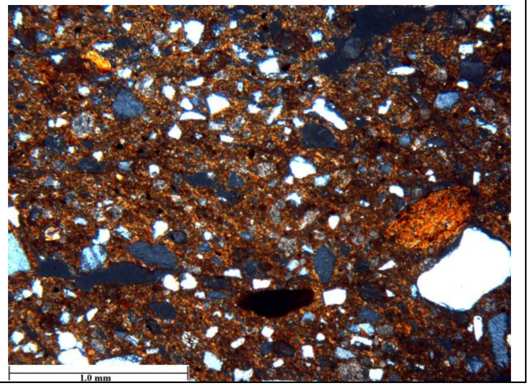
| Ow 12 | **Inclusions:** sand (F2, M1, C1), limestone (F2, M1, C1), black rock particles (F1, C1), red-brown rock particles (C1, M1), large unmixed clay pellets<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 5 mm<br>**Surface Colour:** exterior 5YR7/6 (reddish yellow); interior 5YR6/6 (reddish yellow)<br>**Break Colour:** no zones, 5YR5/6 (yellowish red) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM, CAL(s), FOX(s), OP(s), CP, AM, EPI(s), PY(s), SP(s), KYA, SIL<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 2.1; Q/Feld 1.4; Lim 1.4<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim sparse<br>**Colour PPL:** light to medium brown<br>**Colour XPL:** light to medium tan, yellow tinge<br>**Optical Activity:** active | **Clay Type:** Marl A (A2?)<br>**Inclusions:** quartz, limestone, and argillaceous rock fragments<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Egypt<br>**Comments:** clay type and inclusions resemble the Egyptian Marl A fabric |       |

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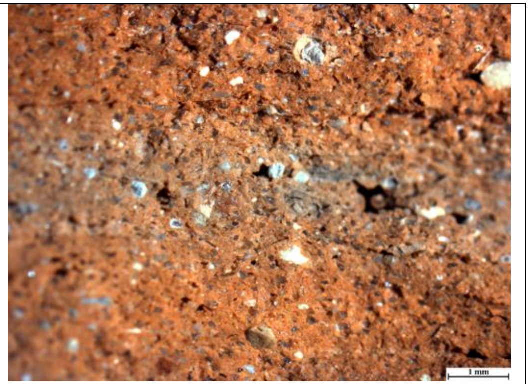
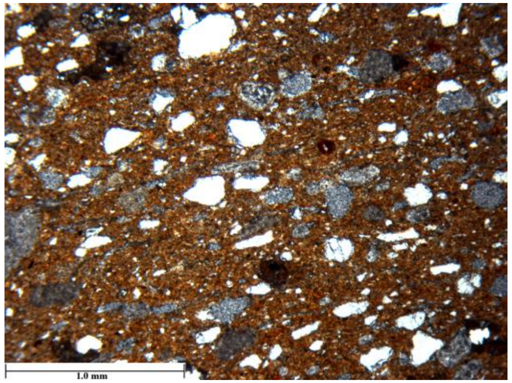
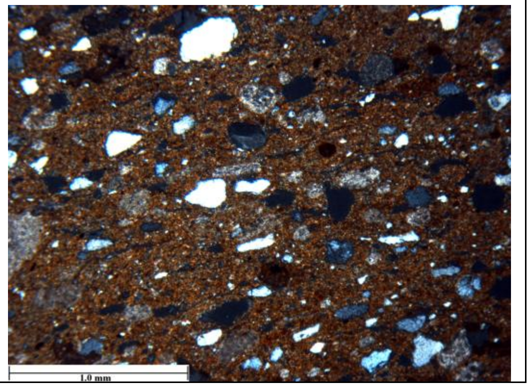
| Ow 13 | **Inclusions:** sand (F2, M2, C1), limestone (F1, M1), grey-white particles (C1), black rock particles (F1), red-brown rock particles (M1, F1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 7.5YR7/6 (reddish yellow); interior 2.5YR6/8 (light red)<br>**Break Colour:** core 7.5YR5/1 (gray); outer zones 5YR6/6 (reddish yellow) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM, CAL(s), MF, FOX(s), OP(s), CP, CHREP, EPI, PY, SP(s), KYA<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 2.1; Q/Feld 1.2; Lim 1.3; Ch 2.1<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim sparse; Ch rare<br>**Colour PPL:** light tan and medium red-brown, one edge light tan<br>**Colour XPL:** tan and medium red-brown, one edge tan<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** quartz, bioclasts, some limestone and chert<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Northern Coastal Palestine<br>**Comments:** similar proportion of quartz and bioclasts suggests the northern coast of Palestine |    |

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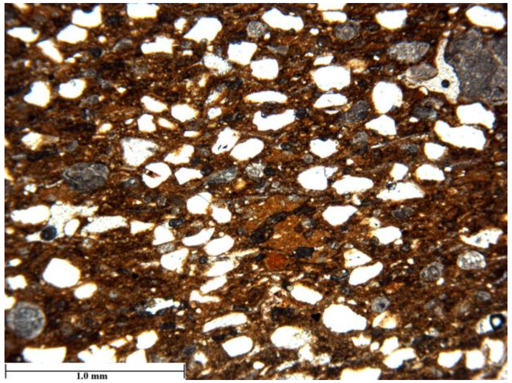
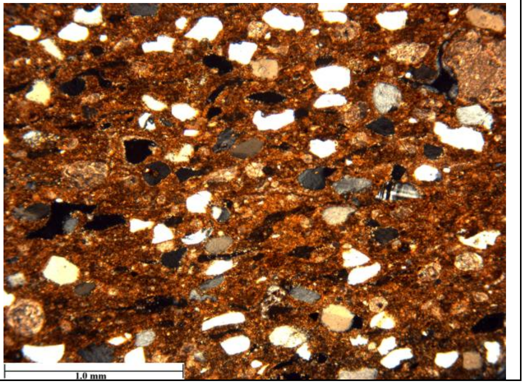
| Ow 14 | **Inclusions:** sand (F2, M2, C1), plant remains (F1), limestone (F1, M1, C1), black rock particles (F1,C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** crumbly<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 2.5YR6/8 (light red); interior 7.5YR6/6 (reddish yellow)<br>**Break Colour:** no zones, 5YR6/8 (reddish yellow) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM, CAL(s), MF, FOX, OP, CP, AM, CHREP, EPI(s), OLV, PY, SP, KYA<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 2.1; Q/Feld 2.1; Lim 1.4; Ch 2.1<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim sparse; Ch rare<br>**Colour PPL:** medium to dark red-brown<br>**Colour XPL:** medium tan<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** quartz, bioclasts, some limestone and chert<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Northern Coastal Palestine<br>**Comments:** similar proportion of quartz and bioclasts suggests the northern coast of Palestine | <br><br> |

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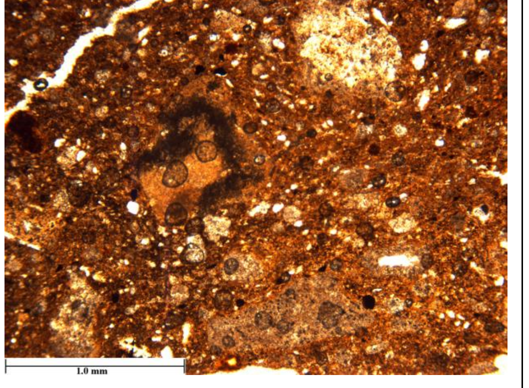
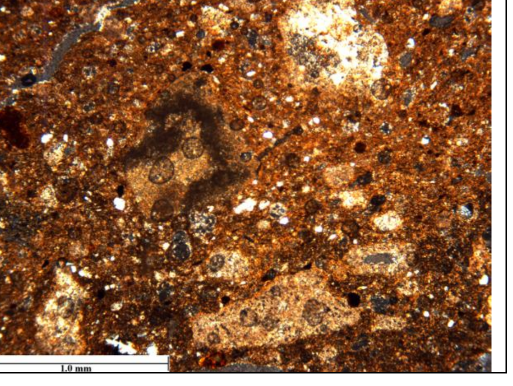
| Ow 15 | **Inclusions:** sand (M1, C2), limestone (F2, M1), black rock particles (F1), red-brown rock particles (C1, M1, F1), shale (C1)<br>**Sorting:** poor<br>**Porosity:** medium<br>**Hardness:** crumbly<br>**Wall Thickness:** 5 mm<br>**Surface Colour:** exterior 10YR6/3 (pale brown) possible combing; interior 10YR6/3 (pale brown)<br>**Break Colour:** no zones, 10YR6/3 (pale brown) | **Inclusions:** QTZ(s), PLG(s), VRF, LIM, CAL(s), MF, FOX(s), OP(s), CP, CHREP, EPI(s), PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 5%<br>**Grain Size Range:** 1.2; Q/Feld 1.1; Lim 1.4; Ch 1.4<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld sparse; Lim sparse; Ch very rare<br>**Colour PPL:** medium brown and tan<br>**Colour XPL:** dark brown and medium tan<br>**Optical Activity:** slightly active | **Clay Type:** rendzina and *Terra Rossa*<br>**Inclusions:** limestone and chalk<br>**Firing:** reduced fired between 700°C to 800°C<br>**Provenance:** Inland Levant<br>**Comments:** generalized sedimentary inclusions widespread in the Levant, but no coastal material | <br><br> |

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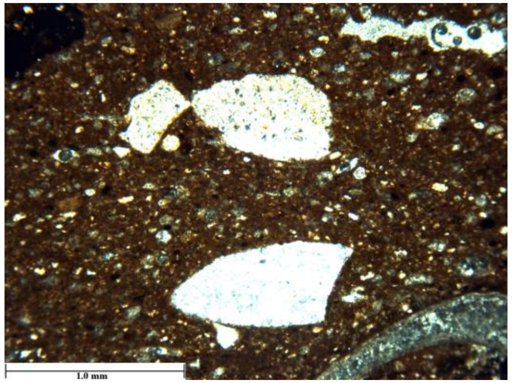
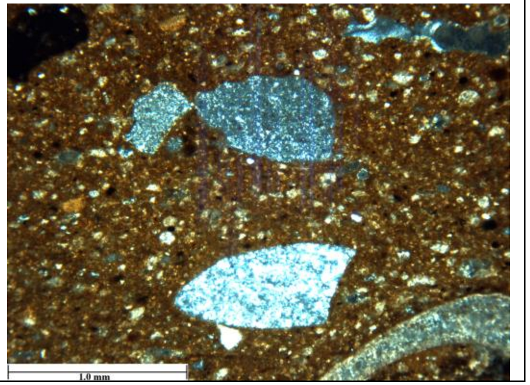
| Ow 16 | **Inclusions:** sand (F1, M1, C1), limestone (F1, M1), black rock particles (C2), red-brown rock particles (F1, C1)<br>**Sorting:** poor<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 10 mm<br>**Surface Colour:** exterior 7.5YR6/6 (reddish yellow); interior 10YR5/2 (greyish brown)<br>**Break Colour:** core 10YR6/1 (gray); outer zones 10YR6/3 (pale brown) | **Inclusions:** QTZ, QIT, MIC, VRF, LIM, CAL(s), MF, FOX, OP, CP, AM, CHA, CHRAD, CHREP(s), PY, SP<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.1; Q/Feld 1.1; Lim 1.4; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch sparse<br>**Colour PPL:** tan to medium brown, red-brown on one edge<br>**Colour XPL:** medium to dark brown, dark red-brown on one edge<br>**Optical Activity:** slightly active | **Clay Type:** Neogene<br>**Inclusions:** basalts, limestone, and chert<br>**Firing:** incompletely oxidized fired between 700°C to 800°C<br>**Provenance:** Akkar Plain<br>**Comments:** Neogene clay is found in northern Lebanon, basalts outcrop in the Akkar Plain | <br><br> |

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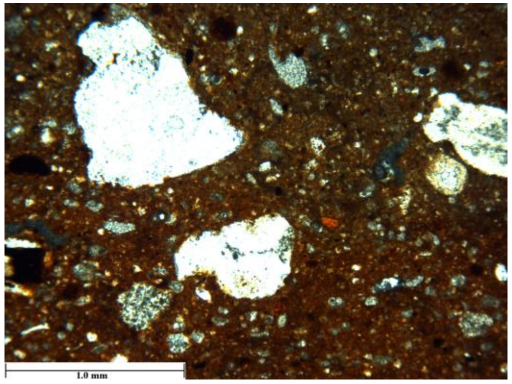
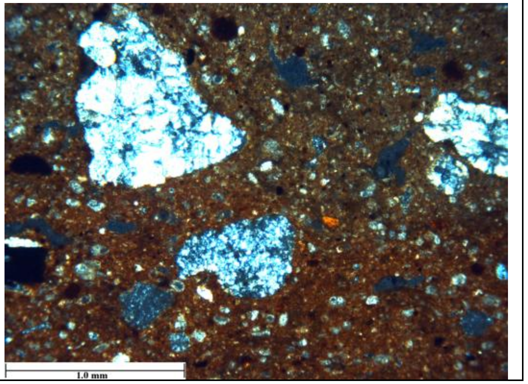
| Ow 17 | **Inclusions:** sand (F1, M1, C1), plant remains (M1), limestone (F1, M1, C1), black rock particles (M1, C1), red-brown rock particles (F1, M1, C1)<br>**Sorting:** poor<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 5YR6/4 (light reddish brown)<br>**Break Colour:** core 7.5YR6/6 (reddish yellow); outer zones 5YR5/6 (yellowish red) | **Inclusions:** QTZ(s), QIT, PLG, MIC(s), VRF, LIM, CAL(s), MF, FOX(s), OP(s), CP, CHA, CHREP(s), PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 20-30%<br>**Grain Size Range:** 1.1; Q/Feld 1.2; Lim 1.3; Ch 1.4<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch rare<br>**Colour PPL:** tan in middle, red-brown on edges<br>**Colour XPL:** tan in middle, red-brown on edges<br>**Optical Activity:** inactive | **Clay Type:** Neogene<br>**Inclusions:** basalts, limestone, and chert<br>**Firing:** oxidized fired between 700°C to 800°C<br>**Provenance:** Akkar Plain<br>**Comments:** Neogene clay is found in northern Lebanon, basalts outcrop in the Akkar Plain | <br><br> |

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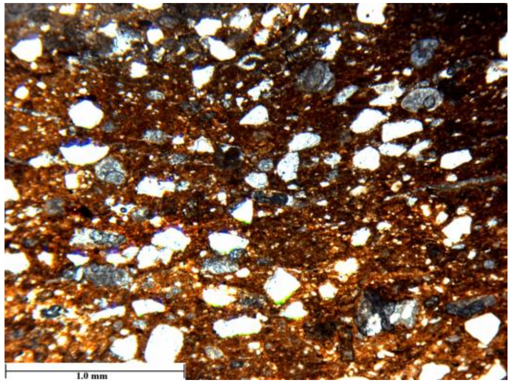
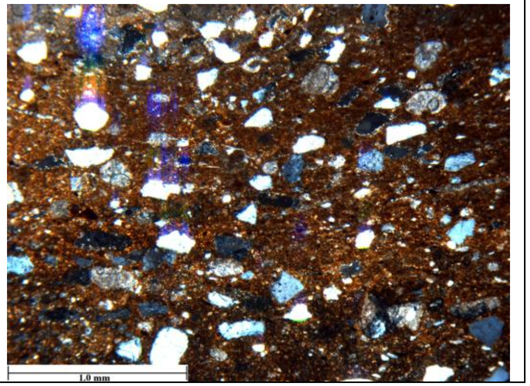
| Ow 18 | **Inclusions:** sand (F2, M2), limestone (F1, M1, C1), grey-white particles (F1), black rock particles (F1, M1), red-brown rock particles (F1, M1)<br>**Sorting:** good<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 6 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 5YR6/6 (reddish yellow)<br>**Break Colour:** core 7.5YR7/6 (reddish yellow); outer zones 5YR6/6 (reddish yellow) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM, CAL, MF, FOX, OP, CP, AM, CHREP, EPI(s), PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.3; Ch 2.0<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim sparse; Ch very rare<br>**Colour PPL:** mix of tan/brown in middle, red-brown and brown on edges<br>**Colour XPL:** mix of tan and brown in middle, red-brown and brown on edges<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** quartz, bioclasts, some limestone and chert<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Northern Coastal Palestine<br>**Comments:** similar proportion of quartz and bioclasts suggests the northern coast of Palestine | <br><br> |

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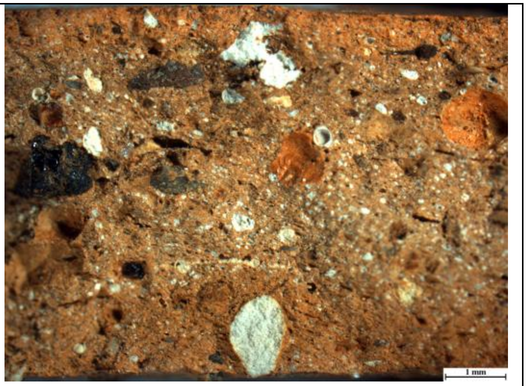
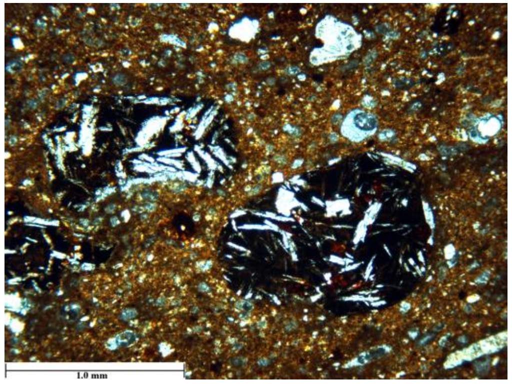
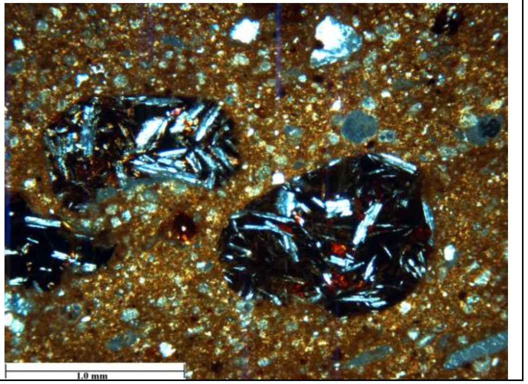
| Ow 19 | **Inclusions:** sand (F1, M1, C1), limestone (F3, M1, C1), black rock particles (C1), red-brown rock particles (F1, M1, C1), shell (F1, M1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 2.5YR6/6 (light red); interior 5YR6/6 (reddish yellow)<br>**Break Colour:** no zones, 5YR6/4 (light reddish brown) | **Inclusions:** QTZ(s), QIT, PLG, MIC, VRF, LIM, CAL(s), MF, FOX(s), OP(s), CP, AM(s), CHA, CHREP, EPI, PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 20-30%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.4<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch sparse<br>**Colour PPL:** red-brown to tan<br>**Colour XPL:** dark red-brown, dark tan<br>**Optical Activity:** slightly active | **Clay Type:** Neogene<br>**Inclusions:** basalts, limestone, and chert<br>**Firing:** oxidized fired between 700°C to 800°C<br>**Provenance:** Akkar Plain<br>**Comments:** Neogene clay is found in northern Lebanon, basalts outcrop in the Akkar Plain |    |

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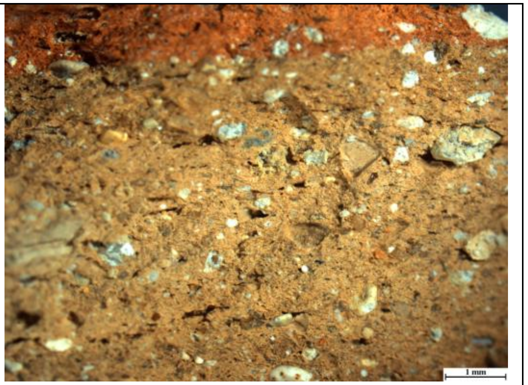
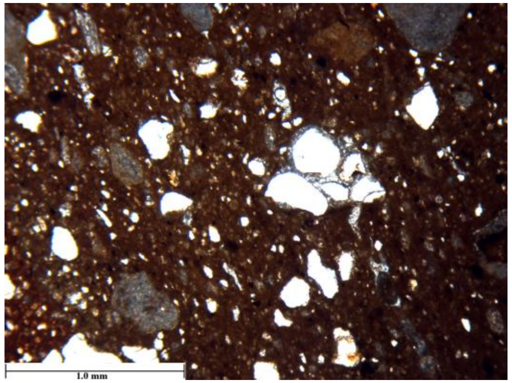
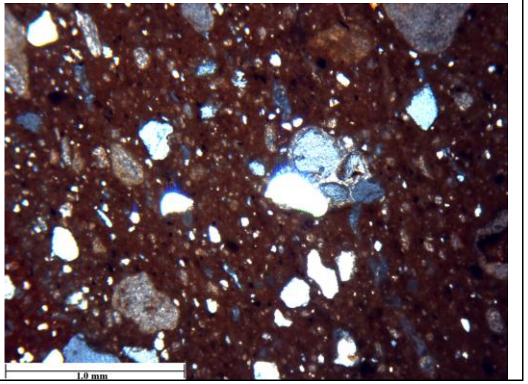
| Ow 20 | **Inclusions:** sand (F1, M1, C1), plant remains (F1), limestone (F2, M2, C1), black rock particles (F1, M1), red-brown rock particles (F1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 10 mm<br>**Surface Colour:** exterior 5YR7/6 (reddish yellow); interior 2.5YR5/6 (red)<br>**Break Colour:** core 7.5YR7/6 (reddish yellow); outer zones 2.5YR5/6 (red) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM(s), CAL, KUK, MF, SH, FOX, OP, CP, AM(s), CHREP, EPI(s), OLV(s), PY(s), SP<br>**Sorting:** poor<br>**Percentage of Inclusions:** 20-30%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.2<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch very rare<br>**Colour PPL:** red-brown on edges, brown to tan in core<br>**Colour XPL:** dark red-brown on edges, dark brown in core<br>**Optical Activity:** inactive | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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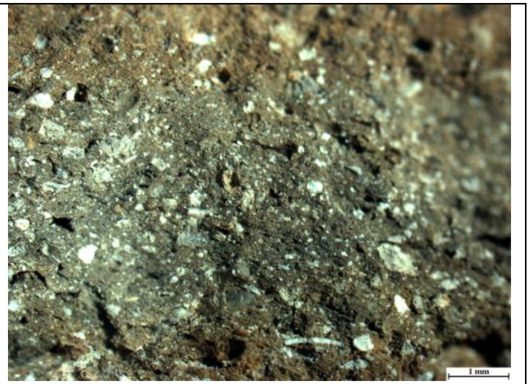
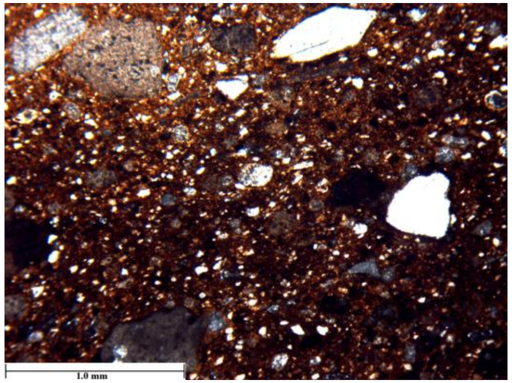
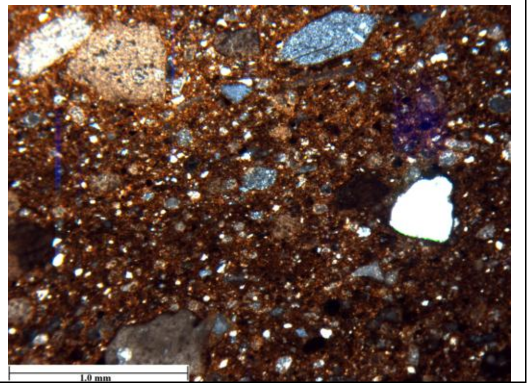
| Ow 21 | **Inclusions:** sand (F1, M1, C1), limestone (F2, M2, C1), black rock particles (F1, M1), red-brown rock particles (F1), shell (VC1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow), burned areas; interior 5YR6/6 (reddish yellow)<br>**Break Colour:** core 7.5YR5/1 (gray); outer zones 7.5YR5/4 (brown) | **Inclusions:** QTZ(s), QIT, PLG, MIC, VGL, LIM(s), CAL, MF, SH, FOX, OP, CP, CHA, CHREP, EPI, PY, TOR<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch sparse<br>**Colour PPL:** red-brown to medium brown to medium red<br>**Colour XPL:** tan to medium brown to medium red<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** reduced fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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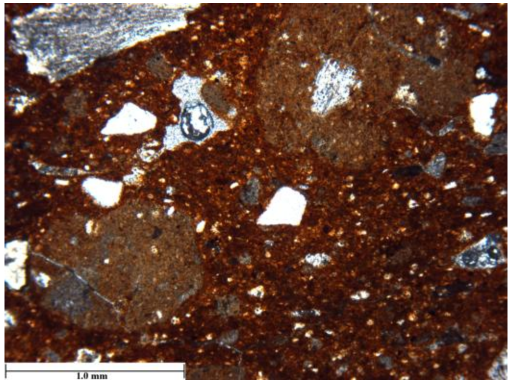
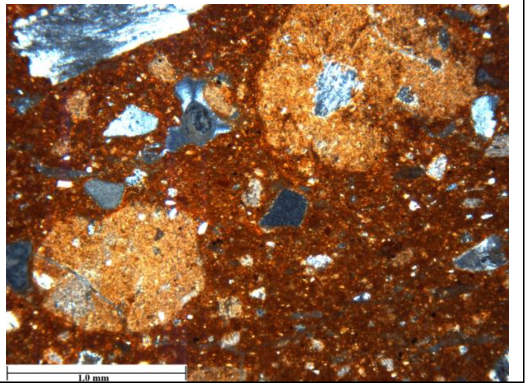
| Ow 22 | **Inclusions:** sand (F1, M2, C1), limestone (F2, M2, C2), black rock particles (F1, C1), red-brown rock particles (F1, M1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 6 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 7.5YR7/6 (reddish yellow)<br>**Break Colour:** no zones, 5YR5/6 (yellowish red) | **Inclusions:** QTZ(s), QIT, MIC, LIM(s), CAL, FOX, OP, CP, CHA, CHREP, PY(s), SP<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch sparse<br>**Colour PPL:** medium red-brown, medium tan on one side<br>**Colour XPL:** dark red-brown, dark tan on one side<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** iron-stained chalk, limestone, chert<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Inland Lebanon<br>**Comments:** sedimentary inclusions and lack of coastal sand suggest slightly inland Lebanon | <br><br> |

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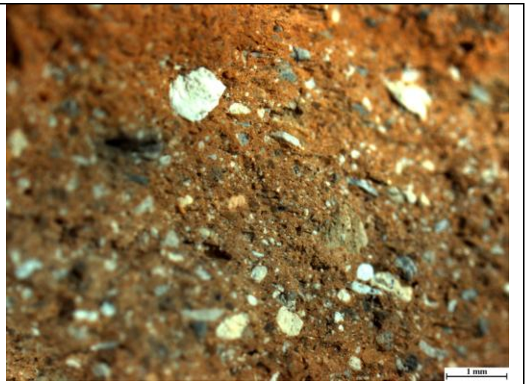
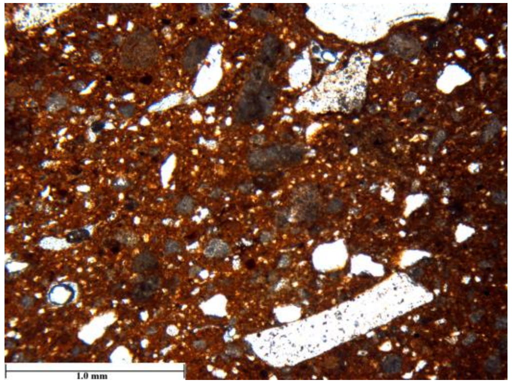
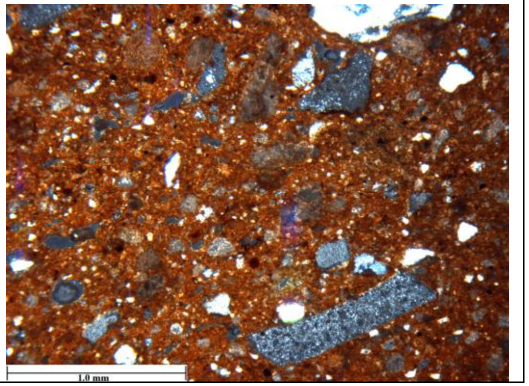
| Ow 23 | **Inclusions:** sand (F1, M1, C1), limestone (F2, M2, C1), black rock particles (F1, M1), red-brown rock particles (F1, M1), shell (M1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 9 mm<br>**Surface Colour:** exterior 7.5YR7/6 (reddish yellow); interior 7.5YR7/6 (reddish yellow)<br>**Break Colour:** core 7.5YR6/2 (pinkish gray); outer zones 5YR6/6 (reddish yellow) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM, CAL, MF, FOX, OP, CP, CHA, CHREP, EPI(s), PY(s), SP(s), TOR<br>**Sorting:** poor<br>**Percentage of Inclusions:** 20-30%<br>**Grain Size Range:** 1.2; Q/Feld 1.3; Lim 1.4; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch sparse<br>**Colour PPL:** medium red-brown<br>**Colour XPL:** medium red-brown<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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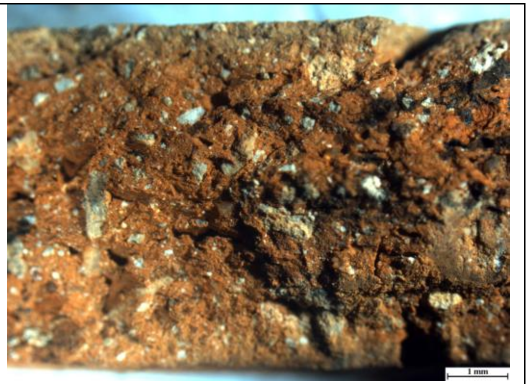
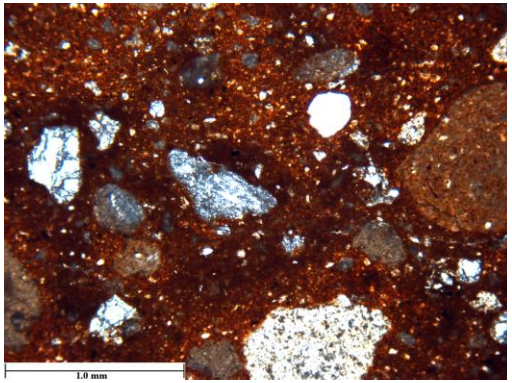
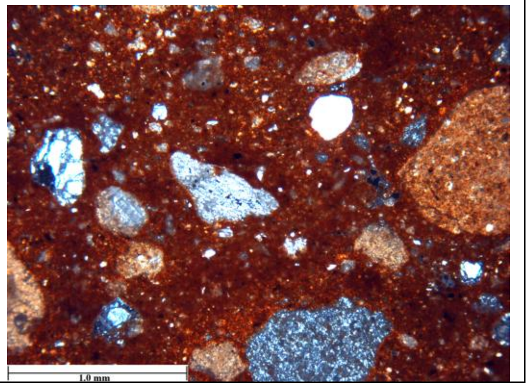
| Ow 24 | **Inclusions:** sand (F1, M1, C1), limestone (F2, M2, C1), black rock particles (C1), red-brown rock particles (F1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 5 mm<br>**Surface Colour:** exterior 2.5YR5/6 (red) with combing; interior 10YR6/4 (light yellowish brown)<br>**Break Colour:** no zones, 2.5YR5/6 (red) | **Inclusions:** QTZ(s), QIT, MIC, LIM, CAL(s), FOX(s), OP(s), CP, CHREP, PY(s), SP<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim abundant; Ch sparse<br>**Colour PPL:** medium red-brown, medium brown on one side<br>**Colour XPL:** dark red-brown, dark brown on one side<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** iron-stained chalk, limestone, chert<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Inland Lebanon<br>**Comments:** sedimentary inclusions and lack of coastal sand suggest slightly inland Lebanon | <br><br> |

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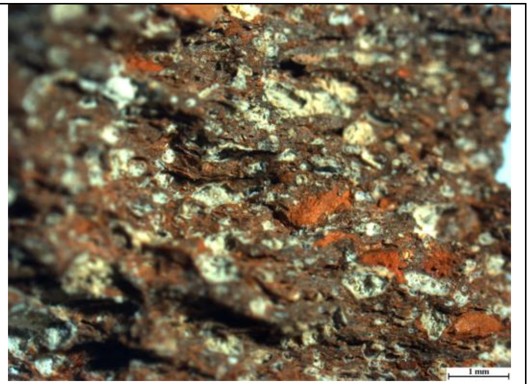
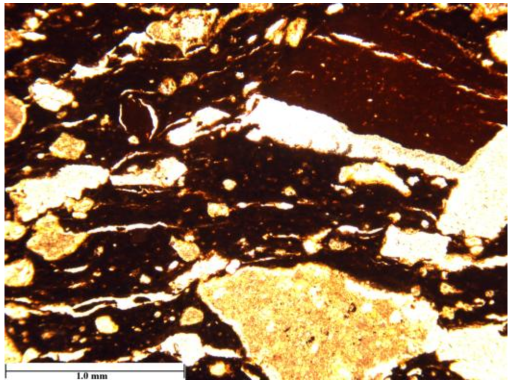
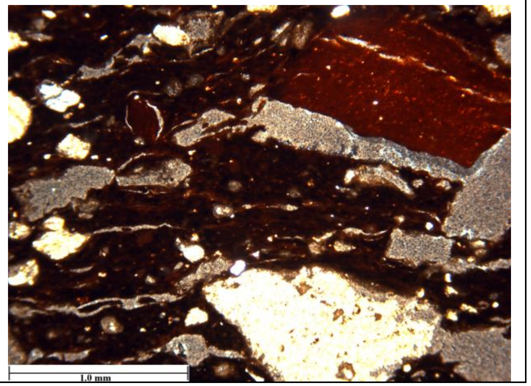
| Ow 25 | **Inclusions:** sand (M1, C1), limestone (F2, M2, C2), black rock particles (F1), unmixed clay pellets (M1, C1)<br>**Sorting:** poor<br>**Porosity:** medium<br>**Hardness:** crumbly<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 2.5YR8/3 (pale yellow); interior 2.5YR6/6 (light red)<br>**Break Colour:** no zones, 5YR5/4 (reddish brown) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM, CAL, FOX, OP(s), CP, AM, EPI(s), PY(s), SP<br>**Sorting:** poor<br>**Percentage of Inclusions:** 5%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld sparse; Lim sparse<br>**Colour PPL:** dark brown, areas of dark red-brown<br>**Colour XPL:** very dark brown, areas of very dark red-brown<br>**Optical Activity:** inactive | **Clay Type:** Marl C (C1?)<br>**Inclusions:** limestone, quartz, and argillaceous rock fragments<br>**Firing:** oxidized fired between 850°C and 900°C<br>**Provenance:** Egypt<br>**Comments:** clay type and inclusions resemble the Egyptian Marl C fabric | <br><br> |

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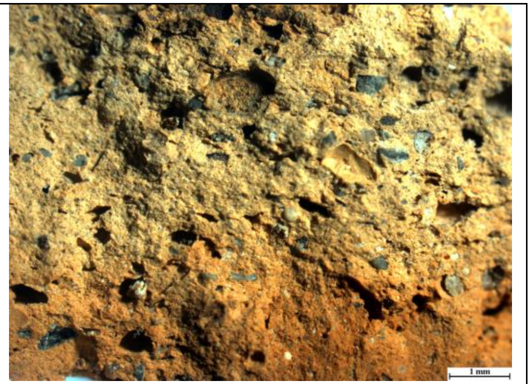
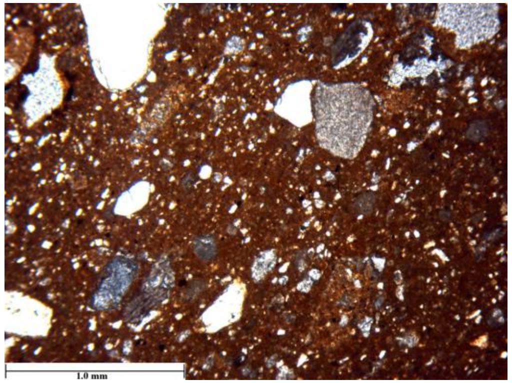
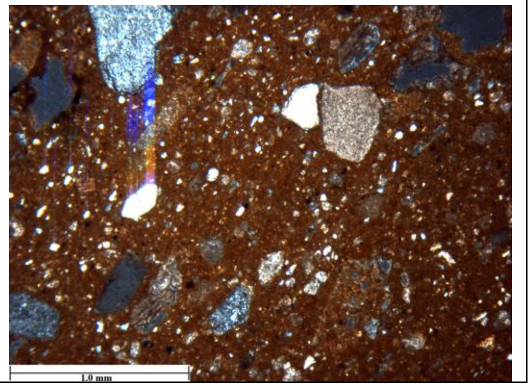
| Ow 26 | **Inclusions:** sand (F1, M2, C1), limestone (F1), black rock particles (F1, M1, C1), red-brown rock particles (F1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** crumbly<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 5YR7/6 (reddish yellow); interior 10YR7/6 (yellow)<br>**Break Colour:** zone towards interior 10YR7/6 (yellow); zone towards exterior 5YR7/6 (reddish yellow) | **Inclusions:** QTZ(s), QIT, PLG, MIC, LIM, CAL(s), MF, FOX(s), OP(s), CP, AM, CHREP, EPI(s), PY(s), SP, TOR<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.3; Lim 1.4; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch sparse<br>**Colour PPL:** medium tan, one edge medium red<br>**Colour XPL:** medium to dark tan, one edge medium to dark red<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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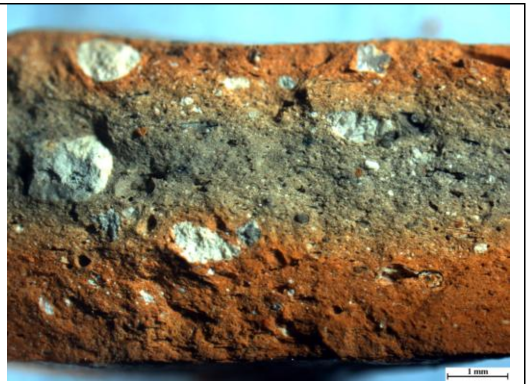
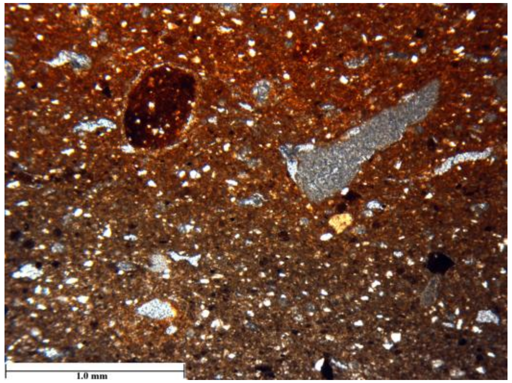
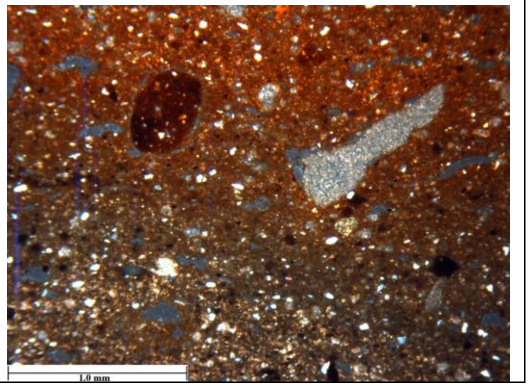
| Ow 27 | **Inclusions:** sand (F1, M1, C1), plant remains (F1), limestone (F2, M1, C1), black rock particles (F1), red-brown rock particles (F1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 5 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 5YR6/6 (reddish yellow)<br>**Break Colour:** zone towards interior 2.5YR5/1 (gray); zone towards exterior 5YR6/6 (reddish yellow) | **Inclusions:** QTZ(s), QIT, LIM, CAL, FOX(s), OP(s), CP, AM(s), EPI(s), PY(s), SP<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.1; Q/Feld 1.1; Lim 1.3<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim abundant<br>**Colour PPL:** middle tan, edges medium red-brown<br>**Colour XPL:** middle tan to dark brown, edges dark to medium red-brown<br>**Optical Activity:** active | **Clay Type:** *Terra Rossa*<br>**Inclusions:** mostly limestone and some quartz<br>**Firing:** oxidized firing between 700°C and 800°C<br>**Provenance:** Levant<br>Comments: generalized sedimentary inclusions | <br><br> |

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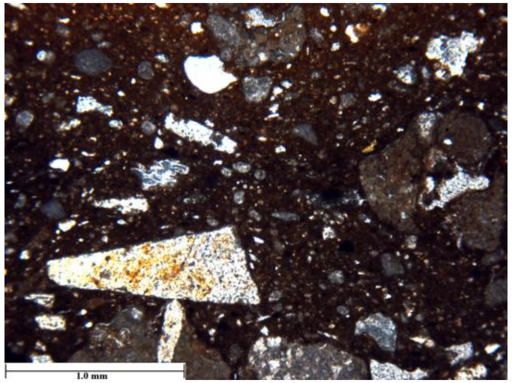
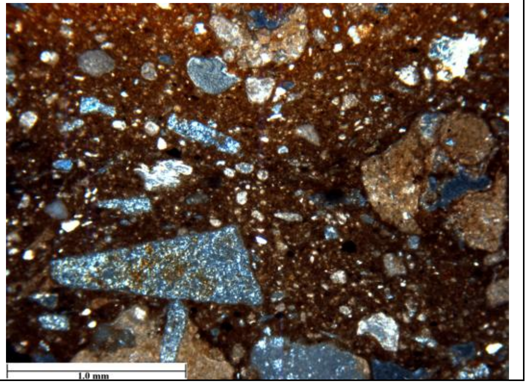
| Ow 28 | **Inclusions:** sand (F1, M2, C1), limestone (F1, M1, C1), black rock particles (F1, M1), red-brown rock particles (F1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 6 mm<br>**Surface Colour:** exterior 2.5YR6/6 (light red) with combing; interior 5YR6/6 (reddish yellow)<br>**Break Colour:** core 10YR5/1 (gray); outer zones 2.5YR6/6 (light red) | **Inclusions:** QTZ(s), QIT, MIC, LIM(s), CAL(s), FOX(s), OP(s), CP, CHA, CHREP(s), EPI, SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.4; Lim 1.4; Ch 1.4<br>**Grain Shape Range:** Q/Feld 1.2, 2.3; Lim 1.3, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim abundant; Ch sparse<br>**Colour PPL:** middle medium brown, edges medium red<br>**Colour XPL:** middle dark brown, edges dark red<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon |  |

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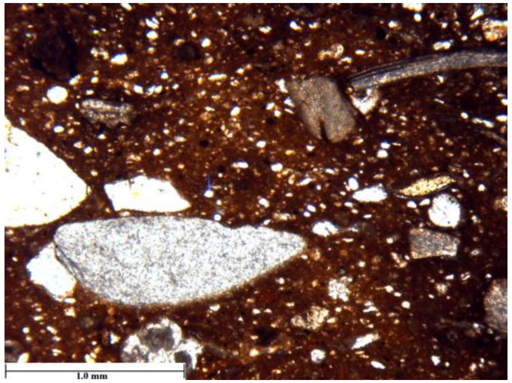
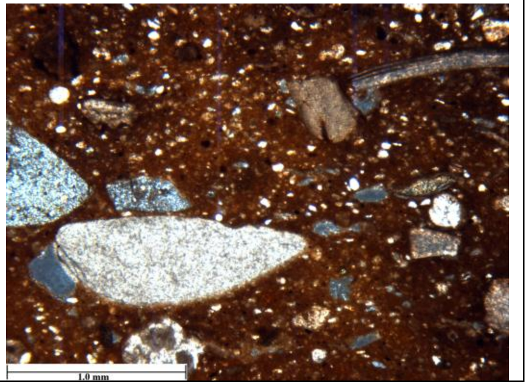
| Ow 29 | **Inclusions:** sand (F1, M2, C1), limestone (F1, M1), black rock particles (F1, M1), red-brown rock particles (F1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior multiple colours; interior 10YR6/4 (light yellowish brown)<br>**Break Colour:** no zones, 7.5YR6/6 (yellowish red) | **Inclusions:** QTZ(s), PLG, LIM(s), CAL(s), MF, SH, FOX(s), OP(s), CP, AM, CHREP, EPI, PY(s), SP, TOR<br>**Sorting:** poor<br>**Percentage of Inclusions:** 20-30%<br>**Grain Size Range:** 1.2; Q/Feld 1.1; Lim 1.4; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.2, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim abundant; Ch rare<br>**Colour PPL:** medium tan to medium reddish tan, one area medium brown<br>**Colour XPL:** dark tan to dark reddish tan, one area dark brown<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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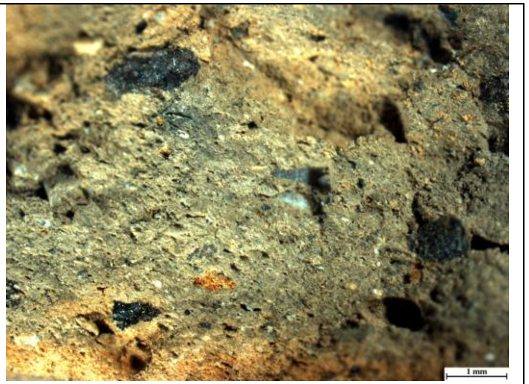
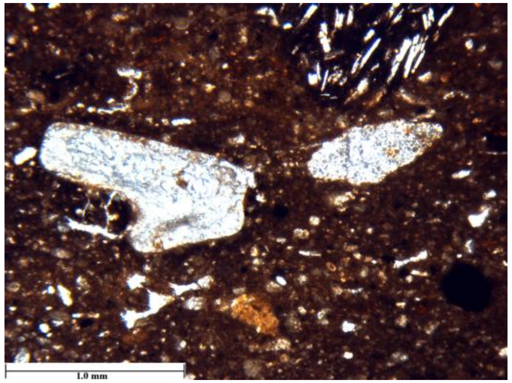
| Ow 30 | **Inclusions:** sand (F1, M1, C1), limestone (F1, M1, C1), black rock particles (F1, C1), red-brown rock particles (F1, M1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 7.5YR7/6 (reddish yellow); interior 10YR7/4 (very pale brown)<br>**Break Colour:** no zones, 2.5YR6/1 (gray) | **Inclusions:** QTZ(s), QIT, PLG(s), MIC, VRF, LIM(s), CAL(s), MF, FOX(s), OP(s), CP, CHA, CHREP(s), PY(s), SP, TOR<br>**Sorting:** poor<br>**Percentage of Inclusions:** 5%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.4<br>**Grain Shape Range:** Q/Feld 1.2, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim abundant; Ch rare<br>**Colour PPL:** medium tan to medium brown<br>**Colour XPL:** dark tan to dark brown<br>**Optical Activity:** slightly active | **Clay Type:** Neogene<br>**Inclusions:** basalts, limestone, and chert<br>**Firing:** oxidized fired between 700°C to 800°C<br>**Provenance:** Akkar Plain<br>**Comments:** Neogene clay is found in northern Lebanon, basalts outcrop in the Akkar Plain | <br><br> |

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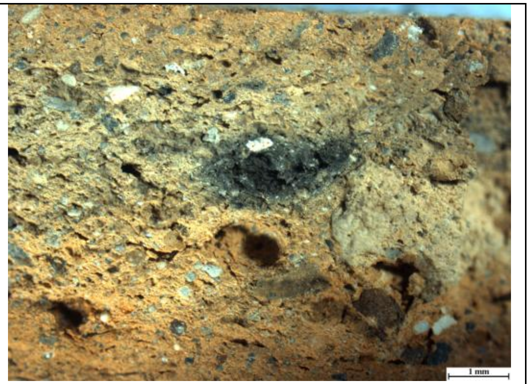
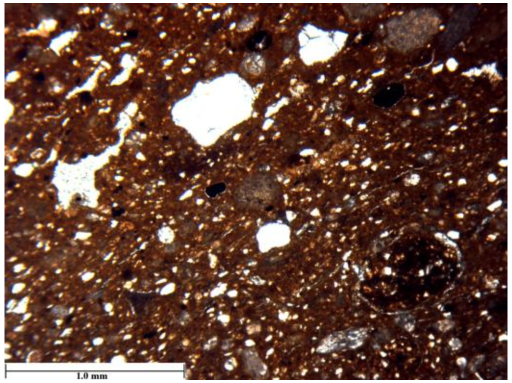
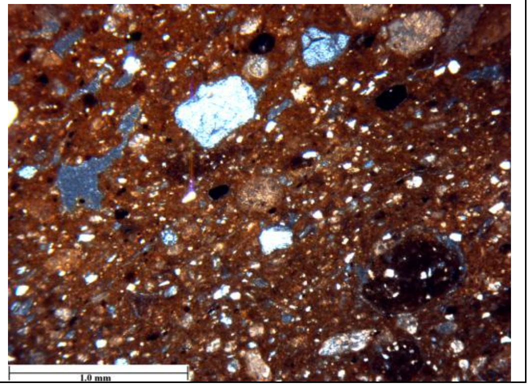
| Ow 31 | **Inclusions:** sand (F2, M1, C1), plant remains (F1), limestone (F1, M1, C1), black rock particles (F1, M1), red-brown rock particles (F1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 5YR7/6 (reddish yellow); interior 10YR6/4 (light yellow brown)<br>**Break Colour:** zone towards interior 2.5Y6/3 (light yellowish brown); zone towards exterior 7.5YR6/6 (reddish yellow) | **Inclusions:** QTZ(s), KF, PLG, LIM, CAL(s), MF, FOX, OP, CP, CHREP, EPI(s), PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.3; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch rare<br>**Colour PPL:** medium red-brown to medium tan<br>**Colour XPL:** dark red-brown to dark brown<br>**Optical Activity:** inactive | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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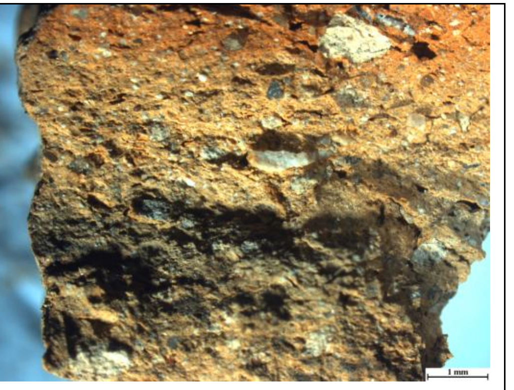
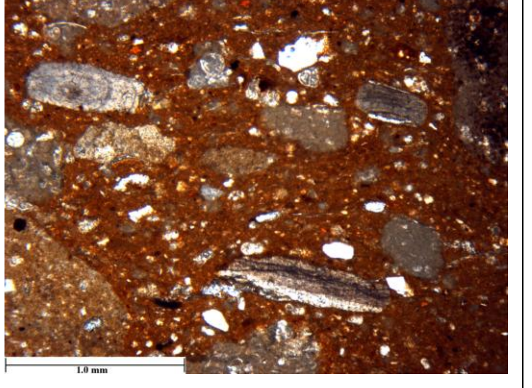
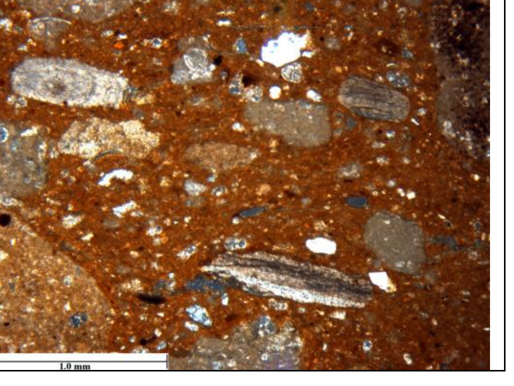
| Ow 32 | **Inclusions:** sand (F1, M1, C1), limestone (F1, M1, C1), black rock particles (F1), red-brown rock particles (F1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 5 YR6/6 (reddish yellow); interior 10YR7/4 (very pale brown)<br>**Break Colour:** core 2.5YR5/1 (gray); outer zones 10YR7/6 (yellow) | **Inclusions:** QTZ(s), QIT, KF, MIC, LIM, CAL, MF, FOX(s), OP(s), CP, CHREP, EPI(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.4<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch rare<br>**Colour PPL:** medium tan, medium red-brown on one side<br>**Colour XPL:** dark tan, dark red-brown on one side<br>**Optical Activity:** inactive | **Clay Type:** foraminiferous marl<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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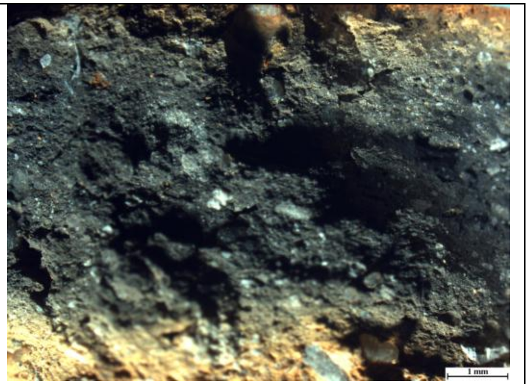
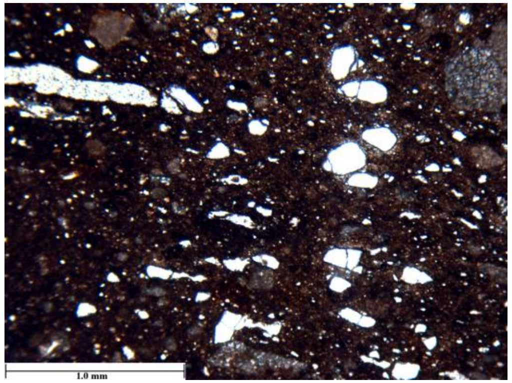
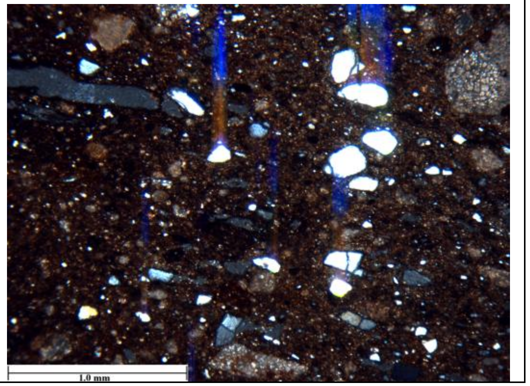
| Ow 33 | **Inclusions:** sand (F1, M1, C1), plant remains (F1), limestone (F1, M1, C1), red-brown rock particles (M1, C1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 10 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 5YR6/6 (reddish yellow)<br>**Break Colour:** core 10YR4/1 (dark gray); outer zones 10YR7/4 (very pale brown) | **Inclusions:** QTZ(s), QIT, KF(s), PLG(s), MIC, LIM(s), CAL(s), MF, FOX(s), OP(s), CP, CHREP, EPI(s), PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.4; Lim 1.4; Ch 1.2<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch rare<br>**Colour PPL:** medium tan, medium red on one side<br>**Colour XPL:** dark tan, dark red on one side<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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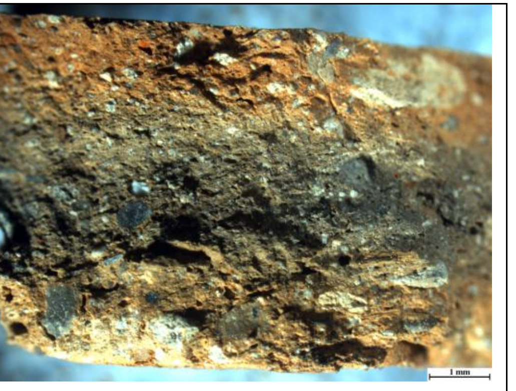
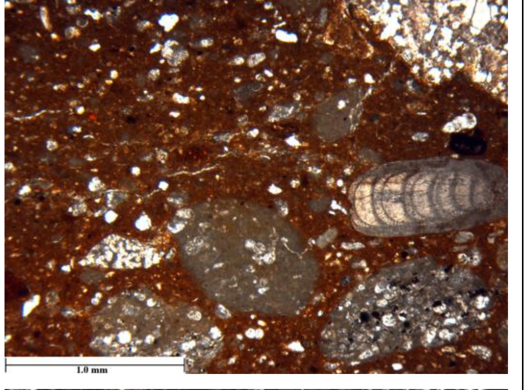
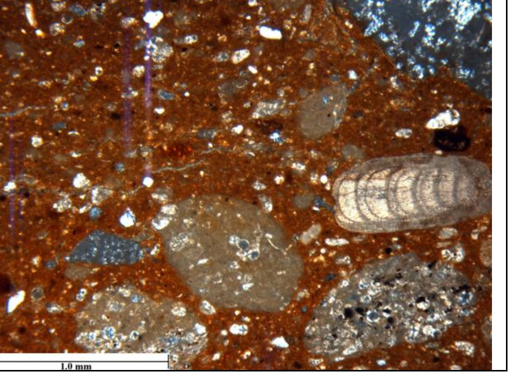
| Ow 34 | **Inclusions:** sand (F1, M1, C1), plant remains (F1), limestone (F1, M1, C1), black rock particles (M1, F1), red-brown rock particles (F1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 6 mm<br>**Surface Colour:** exterior 10YR7/4 (very pale brown); interior 5YR6/4 (light reddish brown)<br>**Break Colour:** core 2.5YR4/1 (dark gray); outer zones 10YR7/4 (very pale brown) | **Inclusions:** QTZ(s), QIT, MIC, LIM(s), CAL(s), MF, FOX(s), OP(s), CP, CHA, CHREP, PY(s), SP, TOR<br>**Sorting:** poor<br>**Percentage of Inclusions:** 20-30%<br>**Grain Size Range:** 1.2; Q/Feld 1.3; Lim 1.4; Ch 1.4<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld sparse; Lim abundant; Ch rare<br>**Colour PPL:** medium red to medium tan, one side with medium brown<br>**Colour XPL:** dark red to dark tan, one side with dark brown<br>**Optical Activity:** slightly active | **Clay Type:** foraminiferous marl<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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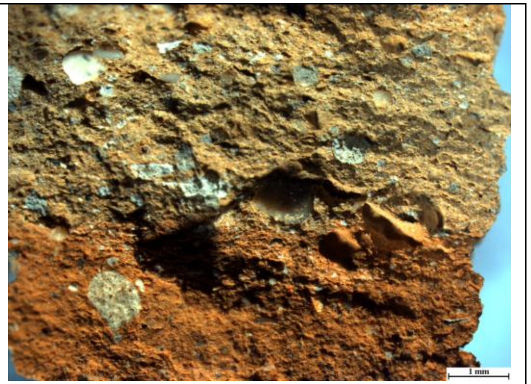
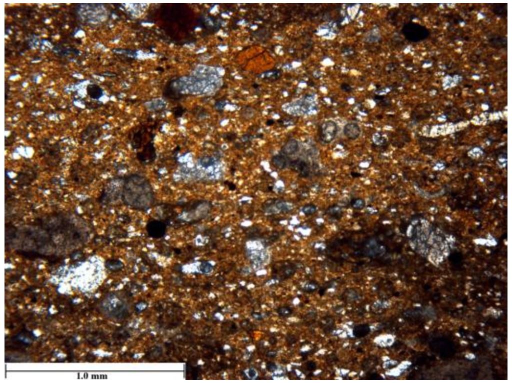
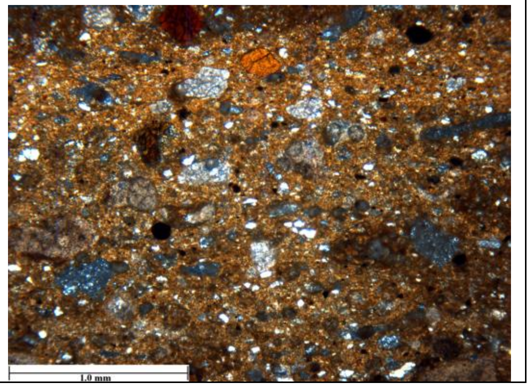
| Ow 35 | **Inclusions:** sand (F1, M1, C1), limestone (F1, M1, C1), grey-white paricles (C1), black rock particles (F1), red-brown particles (F1), red-brown rock particles (F1), shell (F1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 10YR7/6 (yellow)<br>**Break Colour:** core 2.5Y6/1 (gray); outer zones 10YR6/4 (light yellowish brown) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM, CAL, MF, SH, FOX(s), OP(s), AM, CHA, CHREP, EPI(s), PY(s), SP, TOR<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.3; Ch 1.4<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch sparse<br>**Colour PPL:** medium tan, medium red on one side<br>**Colour XPL:** dark tan, dark red on one side<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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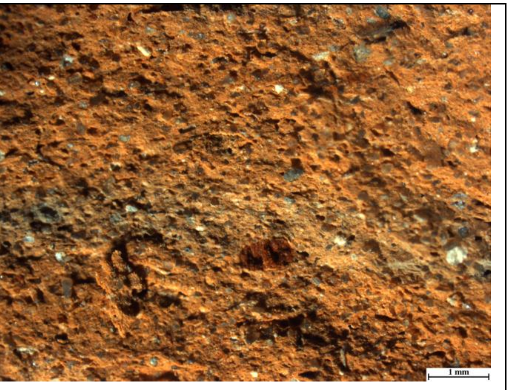
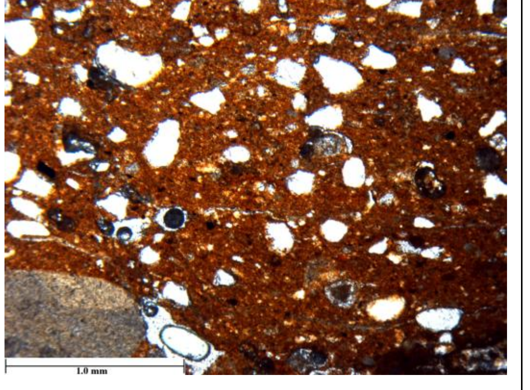
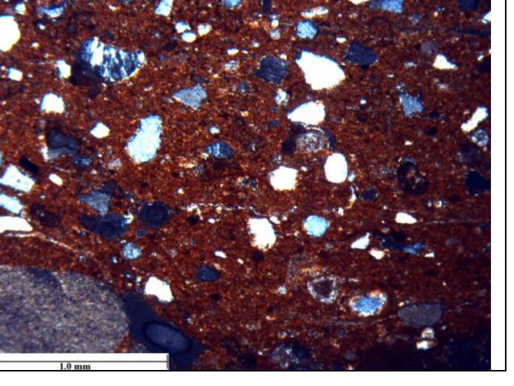
| Ow 36 | **Inclusions:** sand (F3, M1), plant remains (F1), limestone (F1, M1), black rock particles (F1, M1), red-brown rock particles (F1, M1, C1)<br>**Sorting:** good<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 5YR6/4 (light reddish brown) with combing; interior 5YR6/6 (reddish yellow)<br>**Break Colour:** core 10YR5/1 (gray); outer zones 5YR5/6 (yellowish red) | **Inclusions:** QTZ(s), QIT, KF, PLG(s), MIC, LIM(s), CAL(s), MF, FOX(s), OP(s), CP, CHREP, EPI(s), PY(s), SP(s), KYA, STA, TOR<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.2<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim sparse; Ch rare<br>**Colour PPL:** medium reddish tan to medium red-brown<br>**Colour XPL:** dark reddish tan to dark red-brown<br>**Optical Activity:** slightly active | **Clay Type:** rendzina and *Terra Rossa*<br>**Inclusions:** quartz, bioclasts, some limestone and chert<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Northern Coastal Palestine<br>**Comments:** similar proportion of quartz and bioclasts suggests the northern coast of Palestine | <br><br> |

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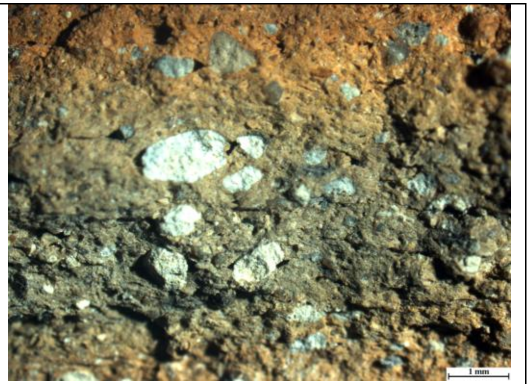
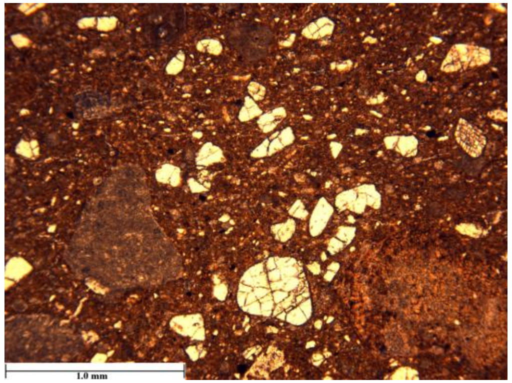
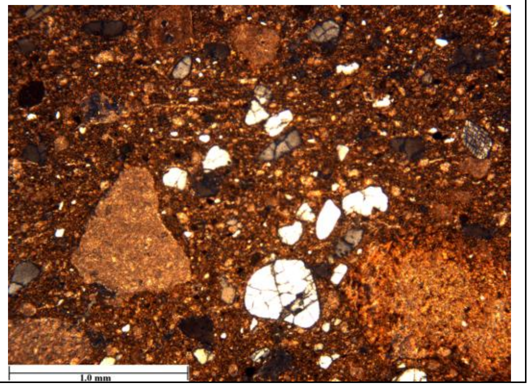
| Ow 37 | **Inclusions:** sand (F2, M1, C1), limestone (F2, M1, C1), black rock particles (F1, C1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 5YR7/6 (reddish yellow); interior 10YR7/4 (very pale brown)<br>**Break Colour:** core 2.5YR6/1 (gray); outer zones 7.5YR6/4 (light brown) | **Inclusions:** QTZ(s), QIT, PLG, LIM, CAL, FOX(s), OP(s), CP, AM, CHREP, EPI(s), PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 2.0<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch very rare<br>**Colour PPL:** medium tan on one side, medium red-brown on the other<br>**Colour XPL:** dark tan on one side, dark red-brown on the other<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** quartz, bioclasts, some limestone and chert<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Northern Coastal Palestine<br>**Comments:** similar proportion of quartz and bioclasts suggests the northern coast of Palestine | <br><br> |

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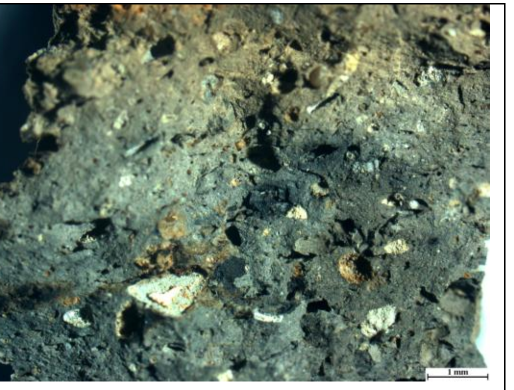
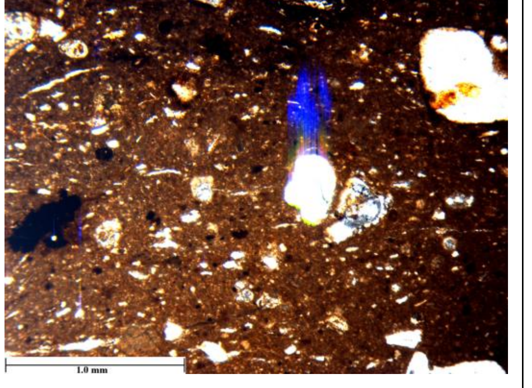
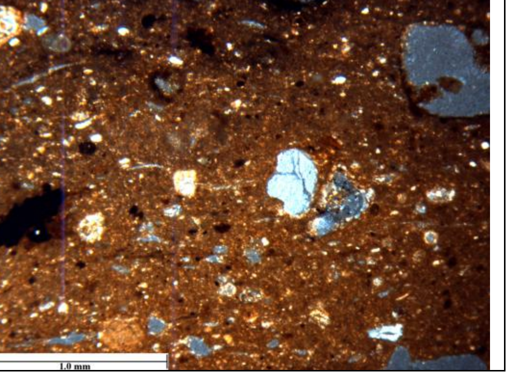
| Ow 38 | **Inclusions:** sand (F1, M1, C1), plant remains (F1), limestone (F1, M1, C1), black rock particles (F1, C1), red-brown rock particles (F1, M1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 9 mm<br>**Surface Colour:** exterior 5YR7/6 (reddish yellow); interior 2.5Y6/3 (light yellowish brown)<br>**Break Colour:** core 2.5Y5/1 (gray); outer zones 2.5Y6/2 (light brownish gray) | **Inclusions:** QTZ(s), QIT, KF(s), MIC, LIM(s), CAL(s), MF, FOX(s), OP(s), CP, AM, CHREP, EPI(s), PY(s), SP(s), TOR<br>**Sorting:** poor<br>**Percentage of Inclusions:** 5%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.3; Ch 2.1<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld sparse; Lim sparse; Ch very rare<br>**Colour PPL:** medium tan, areas of dark brown<br>**Colour XPL:** dark tan, areas of very dark brown to black<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** limestone, chert, and some quartz<br>**Firing:** reduced fired between 700°C and 800°C<br>**Provenance:** Levant<br>Comments: generalized sedimentary inclusions |    |

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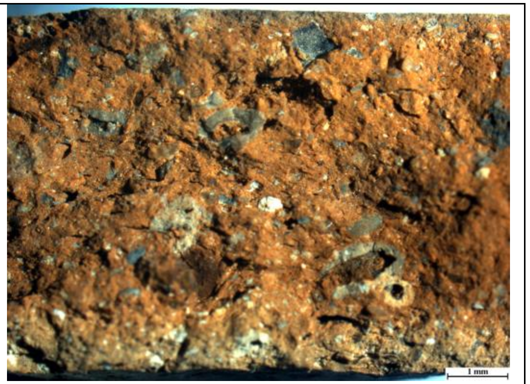
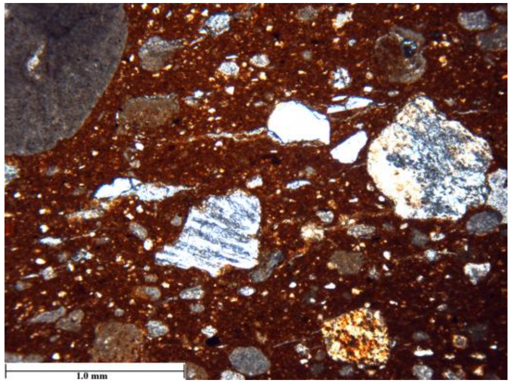
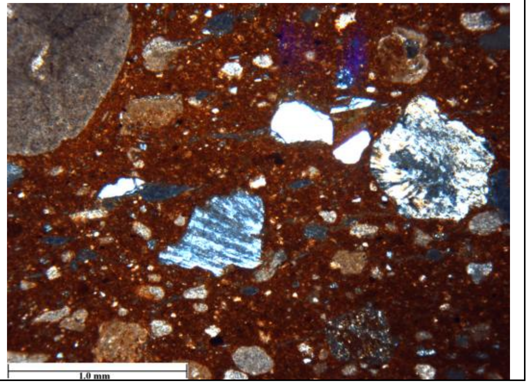
| Ow 39 | **Inclusions:** sand (F1, M2, C1), limestone (F1, M1), black rock particles (F1), red-brown rock particles (F1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 7.5YR5/4 (brown); interior 10YR6/3 (pale brown)<br>**Break Colour:** core 7.5YR4/4 (brown); zone towards interior 2.5YR5/6 (red); zone towards exterior 7.5YR5/6 (strong brown) | **Inclusions:** QTZ(s), QIT, MIC, LIM(s), CAL(s), FOX(s), OP(s), CP, CHA, CHREP(s), EPI(s), PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.3; Q/Feld 1.2; Lim 1.4; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch sparse<br>**Colour PPL:** medium red, edges medium brown<br>**Colour XPL:** dark red, edges dark brown<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** iron-stained chalk, limestone, chert<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Inland Lebanon<br>**Comments:** sedimentary inclusions and lack of coastal sand suggest slightly inland Lebanon | <br><br> |

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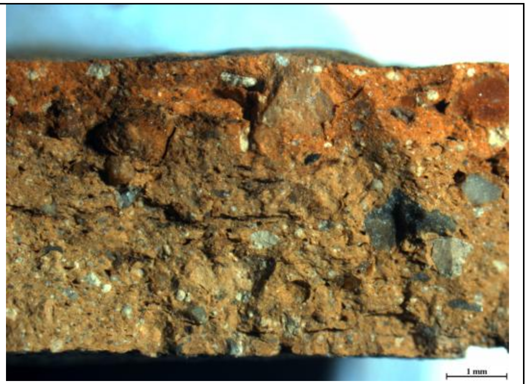
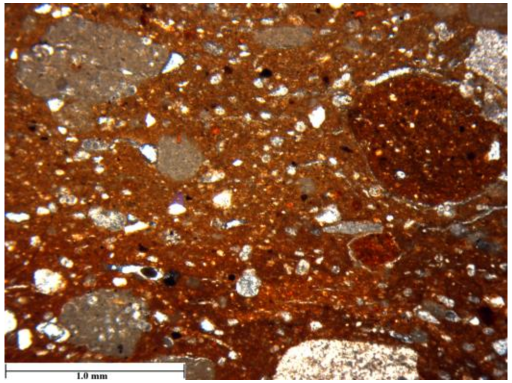
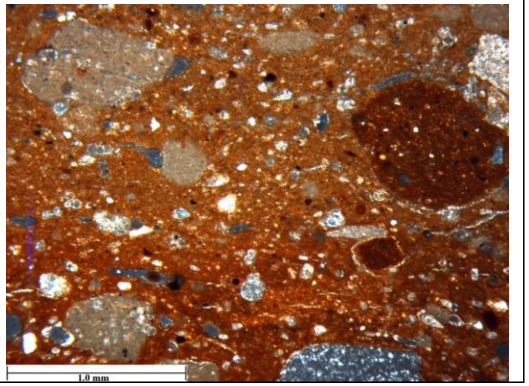
| Ow 40 | **Inclusions:** sand (F1, M1, C1), limestone (F1, M1, C1), black rock particles (F1, M1), red-brown rock particles (F1, M1, C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 5 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 10YR7/4 (very pale brown)<br>**Break Colour:** no zones, 10YR6/4 (light yellow brown) | **Inclusions:** QTZ(s), QIT, LIM(s), CAL(s), MF(s), FOX(s), OP(s), CP, CHA, CHREP, SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.4<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch rare<br>**Colour PPL:** medium tan, medium red on one side<br>**Colour XPL:** dark tan, dark red on one side<br>**Optical Activity:** slightly active | **Clay Type:** foraminiferous marl<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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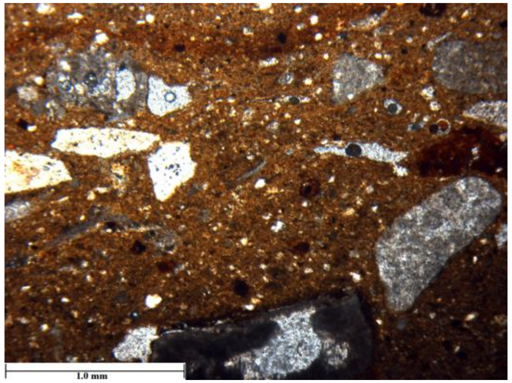
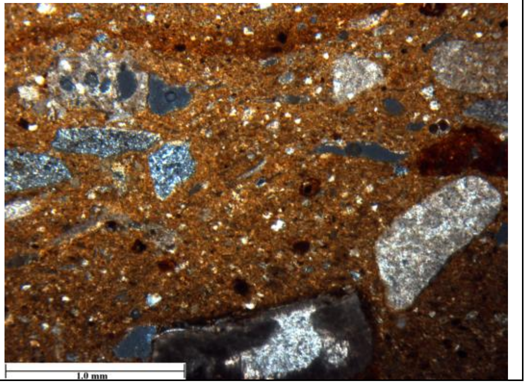
| Ow 41 | **Inclusions:** sand (F1, M2, C1), plant remains (F1, M1), limestone (F2, M1, C1), black rock particles (F1), red-brown rock particles (M1), shale (C1)<br>**Sorting:** good<br>**Porosity:** medium<br>**Hardness:** crumbly<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 7.5YR6/4 (light brown); interior 7.5YR6/4 (light brown)<br>**Break Colour:** core 2.5Y6/2 (light brownish gray); outer zones 7.5YR6/4 (light brown) | **Inclusions:** QTZ(s), QIT, KF(s), PLG(s), LIM(s), FOX(s), OP(s), CP, AM(s), CHREP, EPI, PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch rare<br>**Colour PPL:** medium tan, medium reddish tan on edges<br>**Colour XPL:** dark tan, dark reddish tan on edges<br>Optical Activity: slightly active | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** reduced fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon |    |

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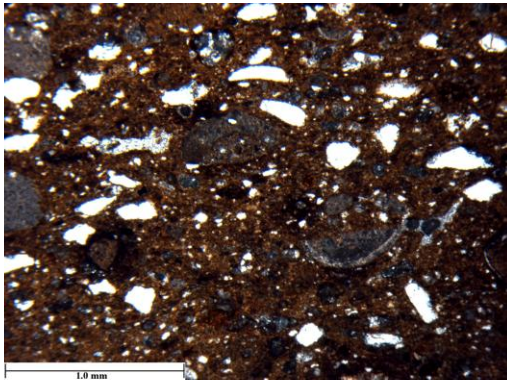
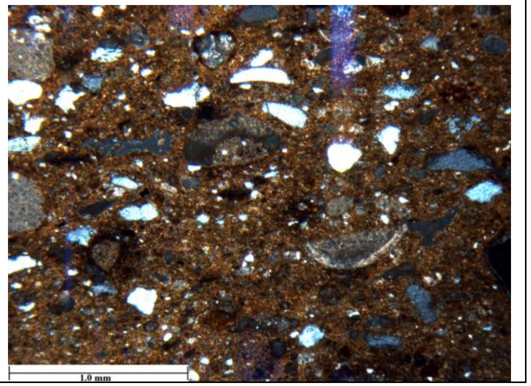
| Ow 42 | **Inclusions:** sand (F1, M2, C1), plant remains (F1), limestone (F1, M1, C1), grey-white particles (F1), black rock particles (F1), red-brown rock particles (F1), shale (C1)<br>**Sorting:** good<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 5YR6/6 (reddish yellow)<br>**Break Colour:** core 2.5Y5/1 (gray); outer zones 10YR6/4 (light yellowish brown) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM(s), CAL(s), MF, SH, FOX(s), OP(s), CP, CHREP, EPI(s), OLV(s), PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 2.1<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch very rare<br>**Colour PPL:** light tan in middle, light reddish orange on edges<br>**Colour XPL:** medium tan in middle, medium reddish orange to orange on edges<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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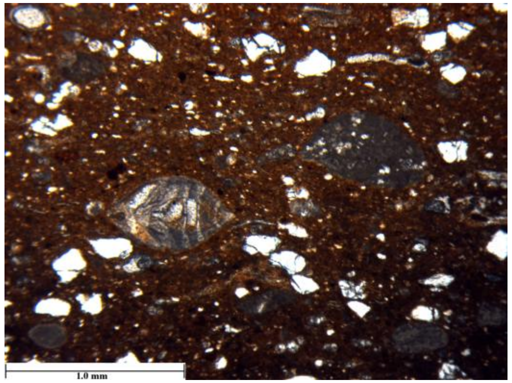
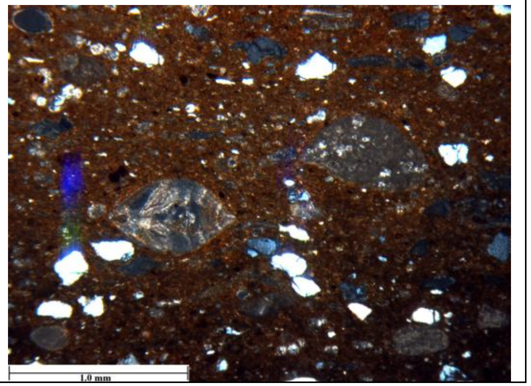
| Ow 43 | **Inclusions:** sand (F1, M2, C1), plant remains (F1, M1), limestone (F1, M1, C1), black rock particles (F1, C1), red-brown rock particles (F1)<br>**Sorting:** good<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 7.5YR6/6 (reddish yellow)<br>**Break Colour:** core 2.5Y5/1 (gray); outer zones 10YR6/4 (light yellowish brown) | **Inclusions:** QTZ(s), QIT, KF, PLG, LIM(s), CAL(s), MF, FOX(s), OP(s), CP, CHREP, EPI(s), PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 2.2<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch very rare<br>**Colour PPL:** medium tan and brown in middle, medium red on edges<br>**Colour XPL:** dark tan and brown in middle, dark red on edges<br>**Optical Activity:** active | **Clay Type:** rendzina<br>**Inclusions:** quartz, bioclasts, some limestone and chert<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Northern Coastal Palestine<br>**Comments:** similar proportion of quartz and bioclasts suggests the northern coast of Palestine |  |

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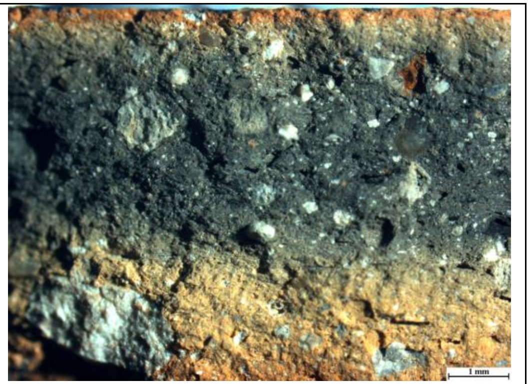
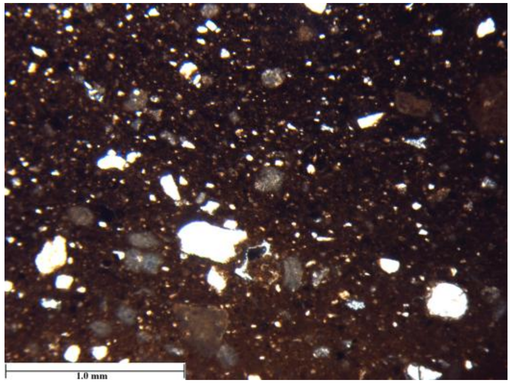
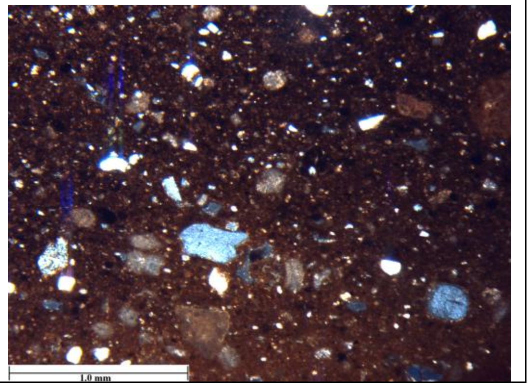
| Ow 44 | **Inclusions:** sand (F1, M1, C1), plant remains (F1), limestone (F2, M1, C1), black rock particles (M1, C1), red-brown rock particles (C1), shell (M1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 5YR7/6 (reddish yellow); interior 5YR6/6 (reddish yellow)<br>**Break Colour:** core 2.5Y4/1 (dark gray); outer zones 10YR6/4 (light yellowish brown) | **Inclusions:** QTZ(s), PLG(s), MIC(s), LIM(s), CAL(s), MF, SH, FOX(s), OP(s), CP, CHREP, EPI(s), PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.1<br>**Grain Shape Range:** Q/Feld 1.2, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch very rare<br>**Colour PPL:** medium tan and brown, medium red on one side (missing other)<br>**Colour XPL:** dark tan and dark brown, dark red on one side<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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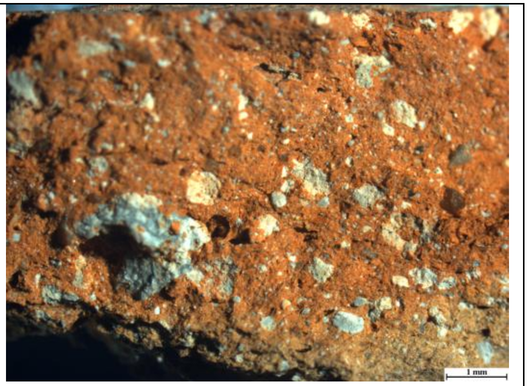
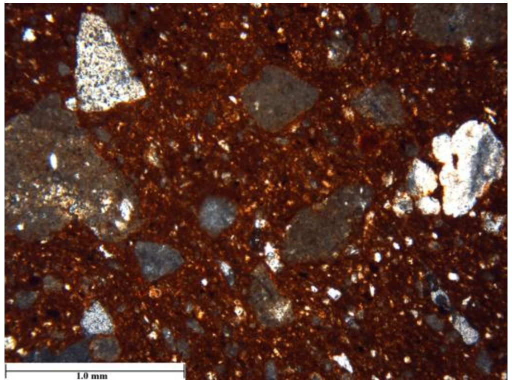
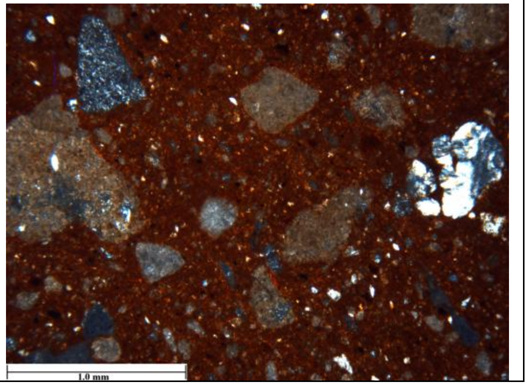
| Ow 45 | **Inclusions:** sand (F1, M1, C1), limestone (F2, M2, C1), black rock particles (F1), red-brown rock particles (F1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 2.5YR5/6 (red); interior 10YR7/4 (very pale brown)<br>**Break Colour:** zone towards interior 7.5YR5/4 (brown); zone towards exterior 2.5YR5/8 (red) | **Inclusions:** QTZ(s), QIT, KF(s), MIC, LIM(s), CAL(s), FOX(s), OP(s), CP, AM, CHA, CHREP, EPI(s), PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.4<br>**Grain Shape Range:** Q/Feld 1.3, 2.3; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch rare<br>**Colour PPL:** medium red-brown, medium tan on one side<br>**Colour XPL:** dark red-brown, dark brown on one side<br>**Optical Activity:** active | **Clay Type:** rendzina<br>**Inclusions:** iron-stained chalk, limestone, chert<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Inland Lebanon<br>**Comments:** sedimentary inclusions and lack of coastal sand suggest slightly inland Lebanon |    |

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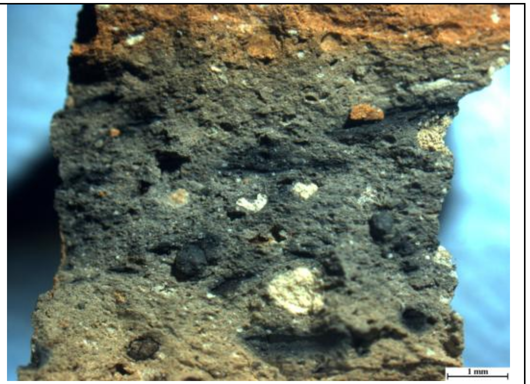
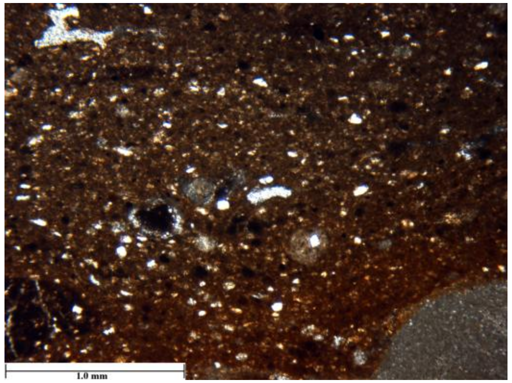
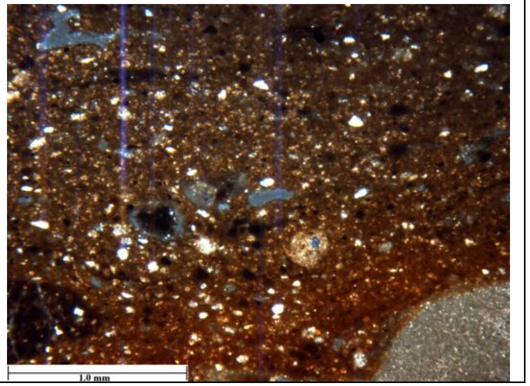
| Ow 46 | **Inclusions:** sand (F1), plant remains (M1), limestone (F1, M1, C1), black rock particles (F1, C1), red-brown rock particles (F1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 7.5YR6/4 (light brown); interior 10YR7/4 (very pale brown)<br>**Break Colour:** core 2.5Y5/1 (gray); zone towards interior 10YR6/4 (light yellowish brown); zone towards exterior 5YR6/6 (reddish yellow) | **Inclusions:** QTZ(s), QIT, KF, PLG, LIM(s), CAL(s), FOX(s), OP(s), CP, AM, EPI(s), PY(s), SP(s), TOR<br>**Sorting:** poor<br>**Percentage of Inclusions:** 5%<br>**Grain Size Range:** 1.2; Q/Feld 1.3; Lim 1.4<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld frequent; Lim frequent<br>**Colour PPL:** medium tan to medium brown, medium red on one side<br>**Colour XPL:** dark tan to dark brown, dark red on one side<br>**Optical Activity:** active | **Clay Type:** rendzina and *Terra Rossa*<br>**Inclusions:** limestone and silt-sized quartz<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Levant<br>Comments: generalized sedimentary inclusions |    |

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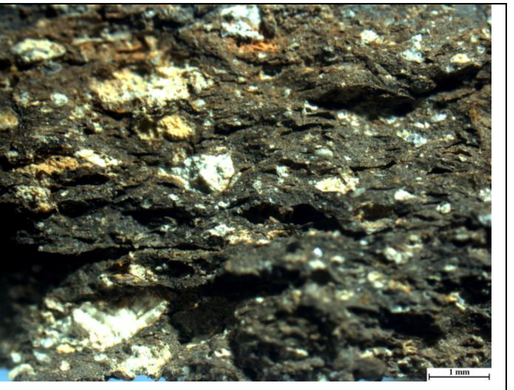
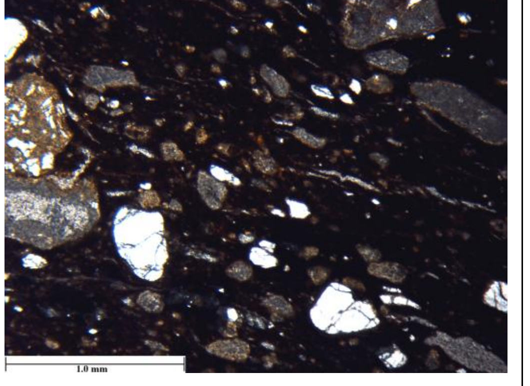
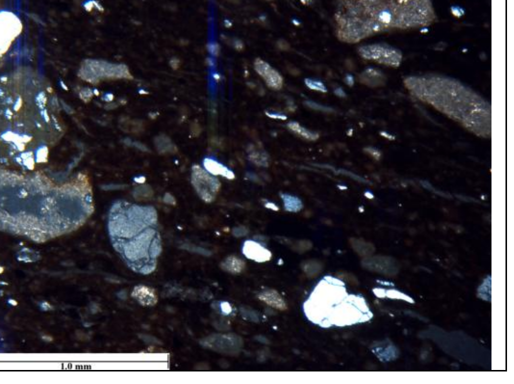
| Ow 47 | **Inclusions:** sand (F1, M1, C1), limestone (F2, M2, C1), black rock particles (F1, C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 7.5YR7/4 (pink); interior 2.5YR6/6 (light red)<br>**Break Colour:** no zones, 10YR5/1 (gray) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM(s), CAL, FOX(s), OP(s), CP, AM, CHREP, EPI, PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.3; Lim 1.4; Ch 2.1<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld frequent; Lim frequent; Ch very rare<br>**Colour PPL:** medium brown, dark brown on one side<br>**Colour XPL:** dark brown, very dark brown on one side<br>**Optical Activity:** inactive | **Clay Type:** *Hamra*<br>**Inclusions:** limestone and some quartz<br>**Firing:** reduced fired between 700°C and 800°C<br>**Provenance:** Levant<br>Comments: generalized sedimentary inclusions |    |

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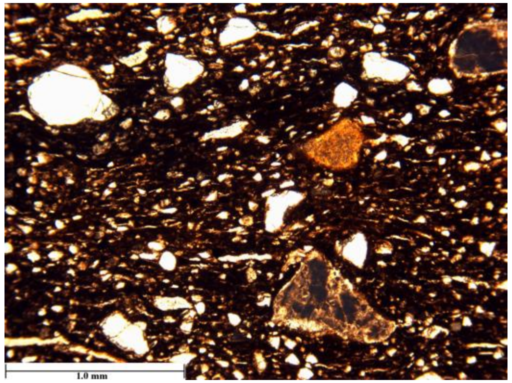
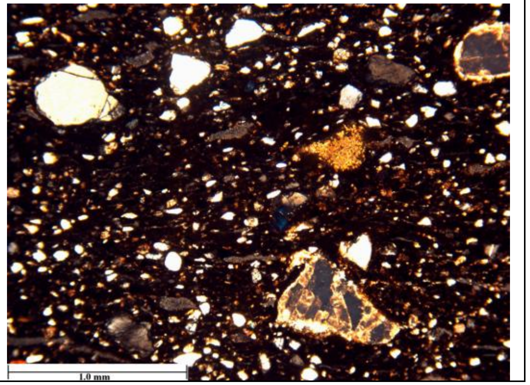
| Ow 48 | **Inclusions:** sand (F1, M1, C1), black rock particles (F1, C1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** crumbly<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 10YR7/4 (very pale brown); interior 5YR7/6 (reddish yellow)<br>**Break Colour:** core 5Y5/1 (gray); zone towards interior 2.5Y6/2 (light brownish gray) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, LIM, CAL, MF, FOX(s), OP(s), AM, CHREP, EPI, OLV, PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 5%<br>**Grain Size Range:** 1.2; Q/Feld 1.3; Lim 1.4; Ch 1.1<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld abundant; Lim frequent; Ch very rare<br>**Colour PPL:** medium brown, medium reddish tan on edges<br>**Colour XPL:** dark brown, dark reddish tan on edges<br>**Optical Activity:** active | **Clay Type:** loess<br>**Inclusions:** silt-sized quartz, kurkar, and some limestone and larger quartz grains<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Southern Palestine<br>**Comments:** loess suggests southern Palestine, while kurkar indicates a location near the coast | <br><br> |

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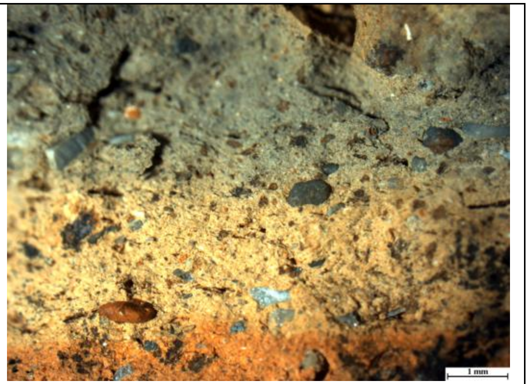
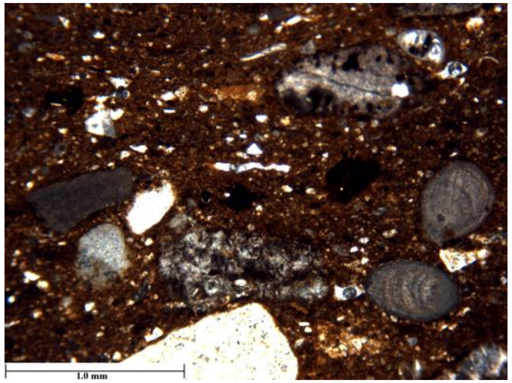
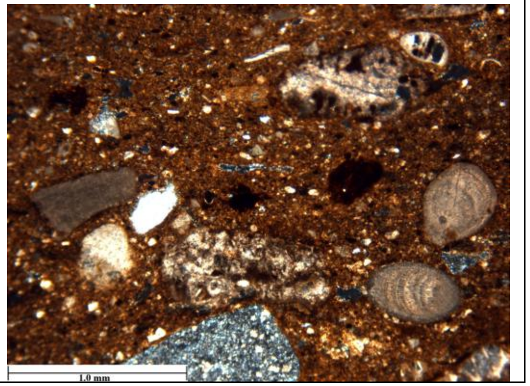
| Ow 49 | **Inclusions:** sand (F1, M1, C1), limestone (F1, M1), black rock particles (F1, M1, C1), red-brown rock particles (F1, C1), shell (M1)<br>**Sorting:** poor<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 10 mm<br>**Surface Colour:** exterior 5YR7/6 (reddish yellow); interior 10YR7/4 (very pale brown)<br>**Break Colour:** core 5Y5/1 (gray); outer zones 10YR6/4 (light yellowish brown) | **Inclusions:** QTZ(s), QIT, PLG, MIC, LIM(s), CAL(s), MF, FOX(s), OP(s), CHA, CHREP, SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 5%<br>**Grain Size Range:** 1.2; Q/Feld 1.1; Lim 1.4; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch rare<br>**Colour PPL:** medium tan, medium red on one side<br>**Colour XPL:** dark tan, dark red on one side<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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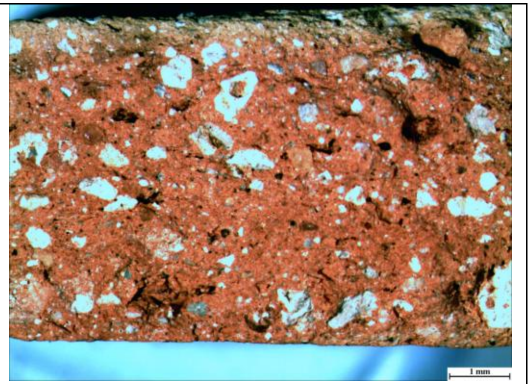
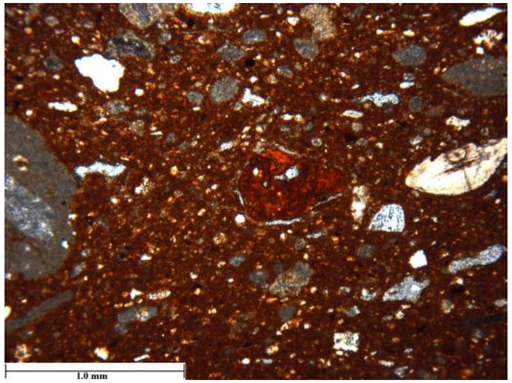
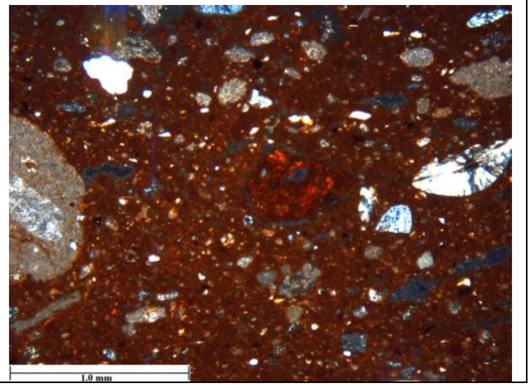
| Ow 50 | **Inclusions:** sand (F2, M1, C1), limestone (F2, M1, C1), black rock particles (F1), red-brown rock particles (F1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 6 mm<br>**Surface Colour:** exterior 2.5YR5/6 (red); interior 10YR7/4 (very pale brown)<br>**Break Colour:** no zones, 5YR6/5 (yellowish red) | **Inclusions:** QTZ(s), QIT, PLG, MIC, LIM(s), CAL(s), FOX(s), OP(s), CP, CHA, CHREP, PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.2<br>**Grain Shape Range:** Q/Feld 1.2, 2.3; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld sparse; Lim abundant; Ch sparse<br>**Colour PPL:** medium red, edges slightly browner<br>**Colour XPL:** dark red, edges slightly browner<br>**Optical Activity:** active | **Clay Type:** rendzina<br>**Inclusions:** iron-stained chalk, limestone, chert<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Inland Lebanon<br>**Comments:** sedimentary inclusions and lack of coastal sand suggest slightly inland Lebanon | <br><br> |

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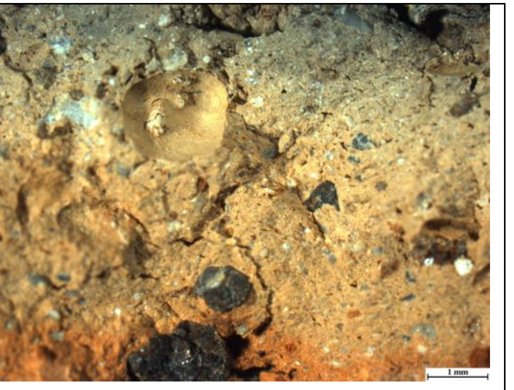
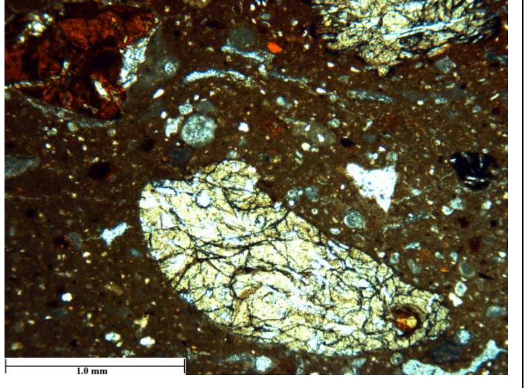
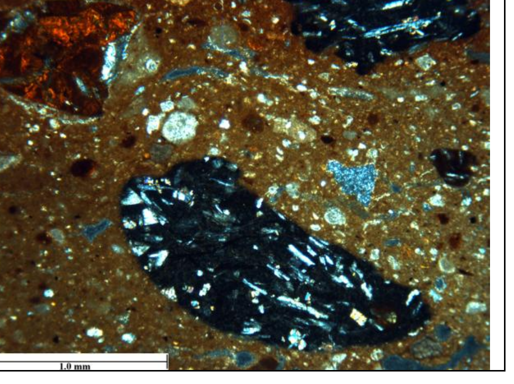
| Ow 51 | **Inclusions:** sand (F1, M1, C1), plant remains (F1), limestone (F2, M1), black rock particles (C1), red-brown rock particles (F1, M1)<br>**Sorting:** fair<br>**Porosity:** dense<br>**Hardness:** medium<br>**Wall Thickness:** 11 mm<br>**Surface Colour:** exterior 5YR7/6 (reddish yellow); interior 10YR7/4 (very pale brown)<br>**Break Colour:** zone towards interior 2.5Y5/1 (gray); zone towards exterior 10YR7/4 (very pale brown) | **Inclusions:** QTZ(s), QIT, PLG, MIC, VRF, LIM(s), CAL(s), MF, FOX, OP(s), CP, CHA, CHREP, PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 5%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.4<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch sparse<br>**Colour PPL:** medium brown, medium tan to medium red<br>**Colour XPL:** dark brown, dark tan to dark red<br>**Optical Activity:** inactive | **Clay Type:** Neogene<br>**Inclusions:** basalts, limestone, and chert<br>**Firing:** oxidized fired between 700°C to 800°C<br>**Provenance:** Akkar Plain<br>**Comments:** Neogene clay is found in northern Lebanon, basalts outcrop in the Akkar Plain |    |

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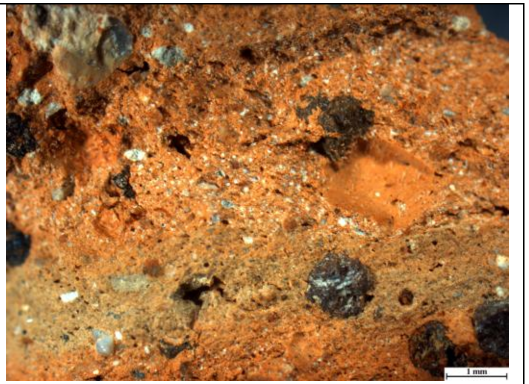
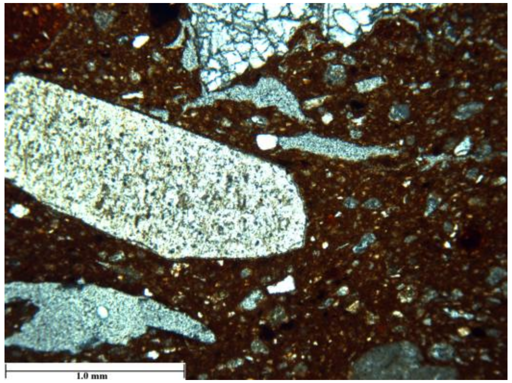
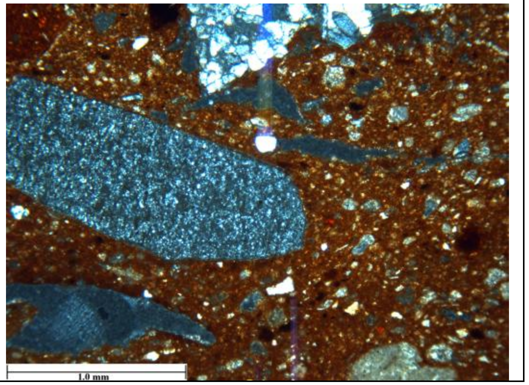
| Ow 52 | **Inclusions:** sand (F1, M1, C1), limestone (F2, M1, C1), black rock particles (F1, C1), red-brown rock particles (F1, C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 2.5YR6/6 (light red); interior 5YR6/8 (reddish yellow)<br>**Break Colour:** core 10YR6/4 (light yellowish brown); zone towards interior 5YR6/8 (reddish yellow); zone towards exterior 5YR6/6 (reddish yellow) | **Inclusions:** QTZ(s), QIT, KF, PLG, MIC, VRF, LIM(s), CAL(s), MF, FOX(s), OP(s), CP, CHA, CHREP, EPI(s), PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.4<br>**Grain Shape Range:** Q/Feld 1.2, 2.3; Lim 1.4, 2.4<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch rare<br>**Colour PPL:** medium red, one are medium tan<br>**Colour XPL:** dark red, one area dark tan<br>**Optical Activity:** slightly active | **Clay Type:** Neogene<br>**Inclusions:** basalts, limestone, and chert<br>**Firing:** oxidized fired between 700°C to 800°C<br>**Provenance:** Akkar Plain<br>**Comments:** Neogene clay is found in northern Lebanon, basalts outcrop in the Akkar Plain | <br><br> |

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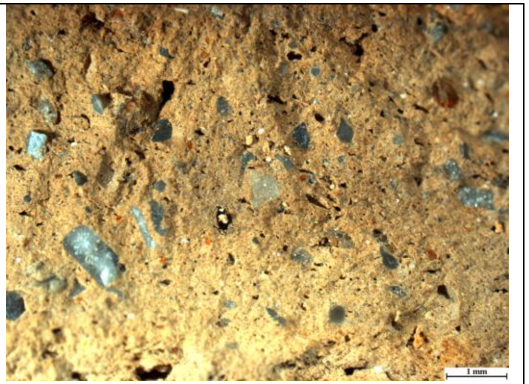
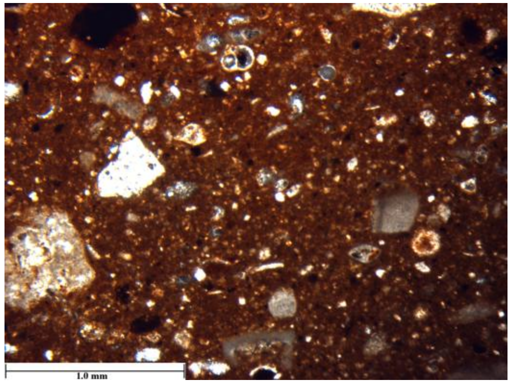
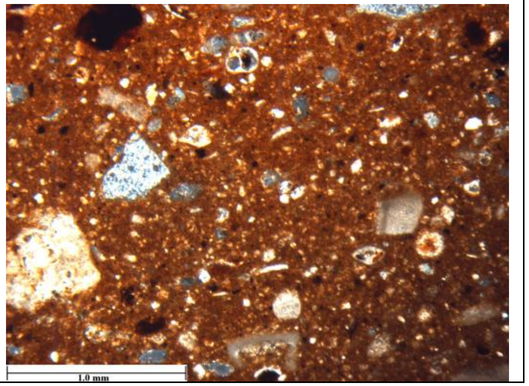
| Ow 53 | **Inclusions:** sand (F1, M1, C1), limestone (F1, M1, C1), black rock particles (F1), red-brown rock particles (F1, M1, C1), shell (M1), shale (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 8 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 7.5YR6/6 (reddish yellow)<br>**Break Colour:** no zones, 10YR6/4 (light yellowish brown) | **Inclusions:** QTZ(s), QIT, PLG, MIC, LIM(s), CAL(s), MF, FOX(s), OP(s), CP, CHREP, SP(s), TOR(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 5%<br>**Grain Size Range:** 1.2; Q/Feld 1.1; Lim 1.3; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch rare<br>**Colour PPL:** medium tan to medium tan-brown and tan-red<br>**Colour XPL:** dark tan to dark tan-brown and tan-red<br>**Optical Activity:** slightly active | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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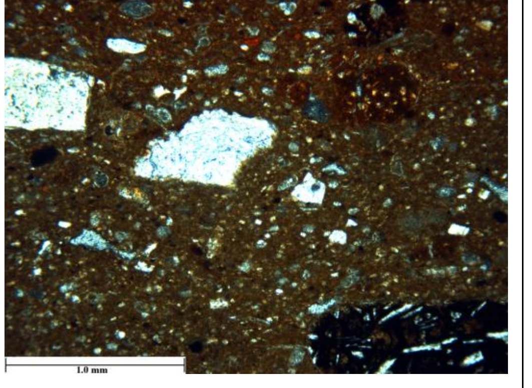
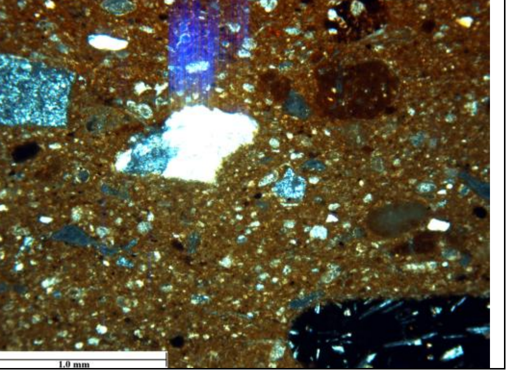
| Ow 54 | **Inclusions:** sand (F1, M1, C1), limestone (F1, M1), black rock particles (F1, C1), red-brown rock particles (F1, M1), shell (C1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 9 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 5YR6/6 (reddish yellow)<br>**Break Colour:** core 10YR6/4 (light yellowish brown); outer zones 5YR6/6 (reddish yellow) | **Inclusions:** QTZ(s), QIT, PLG, MIC, VRF, LIM(s), CAL(s), MF, FOX(s), OP(s), CP, CHA, CHREP, PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.3; Lim 1.4; Ch 1.4<br>**Grain Shape Range:** Q/Feld 1.2, 2.3; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch sparse<br>**Colour PPL:** medium tan in middle, medium reddish tan on edges<br>**Colour XPL:** dark tan in middle, dark reddish tan on edges<br>**Optical Activity:** slightly active | **Clay Type:** Neogene<br>**Inclusions:** basalts, limestone, and chert<br>**Firing:** oxidized fired between 700°C to 800°C<br>**Provenance:** Akkar Plain<br>**Comments:** Neogene clay is found in northern Lebanon, basalts outcrop in the Akkar Plain | <br><br> |

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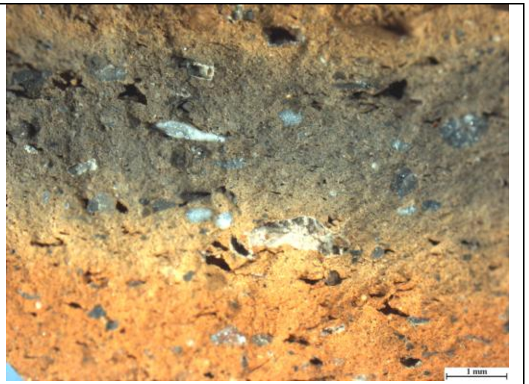
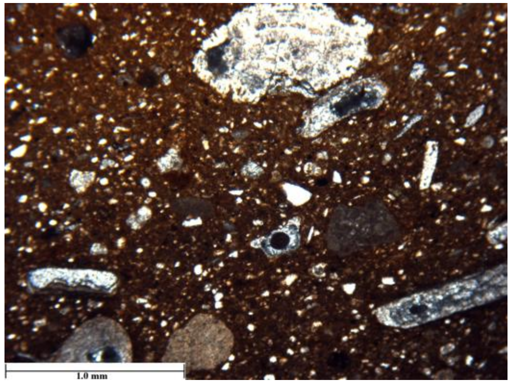
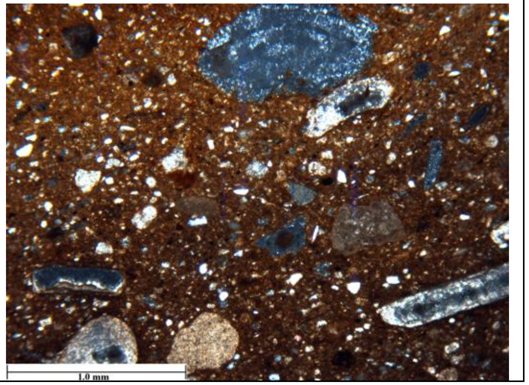
| Ow 55 | **Inclusions:** sand (F1, M1, C1), plant remains (F1), black rock particles (F1, M1), red-brown rock particles (F1, M1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 7 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 10YR6/4 (light yellowish brown)<br>**Break Colour:** core 2.5Y5/1 (gray); outer zones 10YR6/4 (light yellowish brown); zone towards exterior 5YR5/6 (yellowish red) | **Inclusions:** QTZ(s), QIT, PLG, LIM(s), CAL(s), MF, SH, FOX(s), OP(s), CP, AM, CHA, CHREP, EPI(s), PY(s), SP(s), TOR<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.2; Lim 1.4; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.2, 2.3; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch rare<br>**Colour PPL:** medium tan with medium brown core, one edge medium red<br>**Colour XPL:** dark tan with dark brown core, one edge dark red<br>**Optical Activity:** inactive | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** incompletely oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

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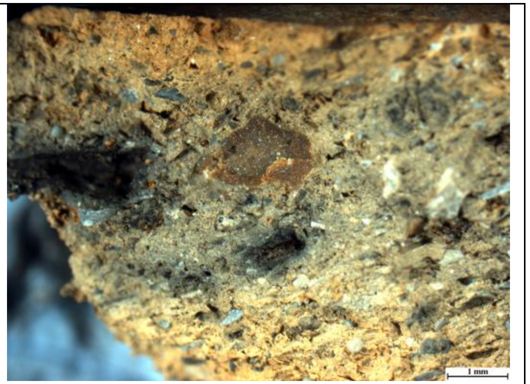
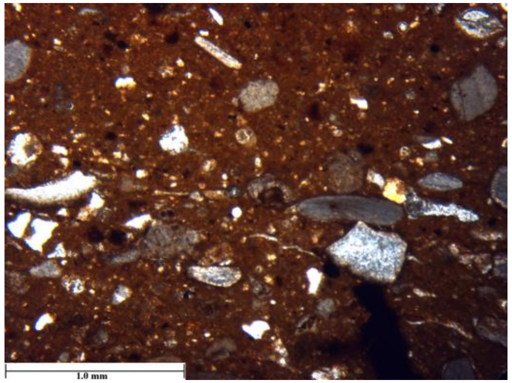
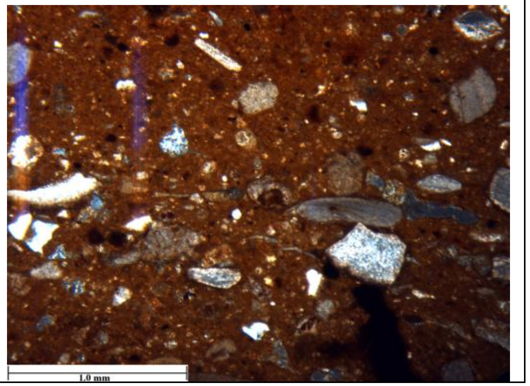
| Ow 56 | **Inclusions:** sand (F1, M2, C1), plant remains (F1, M1), limestone (F1), grey-white particles (F1), black rock particles (F1), red-brown rock particles (F1)<br>**Sorting:** fair<br>**Porosity:** medium<br>**Hardness:** medium<br>**Wall Thickness:** 10 mm<br>**Surface Colour:** exterior 5YR6/6 (reddish yellow); interior 10YR6/4 (light yellowish brown)<br>**Break Colour:** core 5Y5/1 (gray); outer zones 10YR6/4 (light yellowish brown) | **Inclusions:** QTZ(s), QIT, KF, LIM(s), CAL(s), MF, FOX(s), OP(s), CP, CHA, CHREP, PY(s), SP(s)<br>**Sorting:** poor<br>**Percentage of Inclusions:** 10%<br>**Grain Size Range:** 1.2; Q/Feld 1.3; Lim 1.3; Ch 1.3<br>**Grain Shape Range:** Q/Feld 1.2, 2.2; Lim 1.3, 2.3<br>**Grain Frequency:** Q/Feld sparse; Lim frequent; Ch rare<br>**Colour PPL:** medium tan, medium red on one side<br>**Colour XPL:** dark tan, dark red on one side<br>**Optical Activity:** inactive | **Clay Type:** rendzina<br>**Inclusions:** dominance of bioclasts and limestone, less quartz<br>**Firing:** oxidized fired between 700°C and 800°C<br>**Provenance:** Coastal Lebanon<br>**Comments:** amount of bioclasts and reduced quantity of quartz suggest the coast of Lebanon | <br><br> |

# Appendix III: Chemical Compositional Tables and Raw Data

Table III.1: Assessment of accuracy in ICP-AES data[231]

| Sample | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MgO | CaO | $Na_2O$ | $K_2O$ | $TiO_2$ | $P_2O_5$ | MnO | Ba | Sr | Cr | Ni | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KC10 | 49.3 | 18.3 | 10.3 | 7.9 | 12 | 2.5 | 0.19 | 0.83 | 0.04 | 0.13 | 136 | 349 | 341 | 118 | 222 | 66.3 |
| KC10K* | 48 | 17.4 | 9.9 | 7.7 | 11.9 | 2.4 | 0.20 | 0.84 | 0.09 | 0.13 | 126 | 360 | 330 | 104 | 220 | 60 |
| error | 1.3 | 0.9 | 0.4 | 0.2 | 0.1 | 0.1 | -0.01 | -0.01 | -0.05 | 0.0 | 10 | -11 | 11 | 14 | 2 | 6.3 |
| %error | 2.7 | 5.2 | 4 | 2.6 | 0.84 | 4.2 | 5 | 1.2 | 55.6 | 0.0 | 8 | 3.1 | 3.3 | 13.5 | 0.9 | 10.5 |
| | | | | | | | | | | | | | | | | |
| KC11 | 55.3 | 16.3 | 8.6 | 3.8 | 6.8 | 3.4 | 2.2 | 1.1 | 0.30 | 0.14 | 515 | 388 | 111 | 306 | 226 | 116 |
| KC11K | 55.6 | 16.5 | 8.7 | 4 | 6.9 | 3.3 | 2.2 | 1.1 | 0.32 | 0.14 | 491 | 370 | 111 | 280 | 210 | 119 |
| error | -0.3 | -0.2 | -0.1 | -0.2 | -0.1 | 0.1 | 0.0 | 0.0 | -0.02 | 0.0 | 24 | 18 | 0.0 | 26 | 16 | -3 |
| %error | 0.5 | 1.2 | 1.1 | 5 | 1.4 | 3 | 0.0 | 0.0 | 6.3 | 0.0 | 4.9 | 4.9 | 0.0 | 9.3 | 7.6 | 2.5 |
| | | | | | | | | | | | | | | | | |
| KC12 | 69.9 | 15.2 | 3.1 | 1.2 | 1.8 | 4 | 4.1 | 0.35 | 0.09 | 0.04 | 1588 | 447 | 14.8 | 17.5 | 40.6 | 55.4 |
| KC12K | 69 | 15.2 | 2.8 | 1.2 | 1.8 | 4.2 | 4.3 | 0.35 | 0.12 | 0.05 | 1600 | 460 | 25 | 15 | 30 | 42 |
| error | 0.9 | 0.0 | 0.3 | 0.0 | 0.0 | -0.2 | -0.2 | 0.0 | -0.03 | -0.01 | -12 | -13 | -10.2 | 2.5 | 10.6 | 13.4 |
| %error | 1.3 | 0.0 | 10.7 | 0.0 | 0.0 | 4.8 | 4.7 | 0.0 | 25 | 20 | 0.75 | 2.8 | 40.8 | 16.7 | 35.3 | 31.9 |
| | | | | | | | | | | | | | | | | |
| KC14 | 76.2 | 11.3 | 1.9 | 0.00 | 0.19 | 3.7 | 4.7 | 0.12 | 0.0 | 0.03 | 80.3 | 4.3 | 17.73 | 2.65 | 6.13 | 98.1 |
| KC14K | 77.2 | 11.6 | 1.7 | 0.01 | 0.21 | 3.8 | 4.8 | 0.13 | 0.0 | 0.02 | 112 | 8 | NA | NA | NA | 90 |
| error | -1 | -0.3 | 0.2 | -0.01 | -0.02 | -0.1 | -0.1 | -0.01 | 0.0 | 0.01 | -31.7 | -3.7 | | | | 8.1 |
| %error | 1.3 | 2.6 | 11.8 | 100 | 9.5 | 2.6 | 2.1 | 7.7 | 0.0 | 50 | 28.3 | 46.3 | | | | 9 |
| | | | | | | | | | | | | | | | | |
| RH21 | 52.5 | 17.4 | 9.3 | 3.8 | 5.5 | 2.4 | 3.2 | 1.1 | 0.42 | 0.16 | 759 | 305 | 225 | 564 | 186 | 84.6 |
| RH21K | 53.7 | 17.9 | 9.7 | 4.1 | 5.7 | 2.3 | 3.2 | 1.1 | 0.4 | 0.16 | 754 | 303 | 234 | 578 | 187 | 98 |

[231] The tables give the data as no decimal places for numbers above 100, only one decimal place for numbers 99 to 1 and two decimal places for numbers under 1, however, the analysis of the data in excel used numbers with up to thirteen decimal places. New figures for the error and percentage of error have been calculated for the tables based on the rounded numbers but are not significantly different from the unrounded figures in the excel database. The percentage of error is always given as a positive number. Major elements are expressed as wt%, while minor and trace elements are in ppm.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| error | -1.2 | -0.5 | -0.4 | -0.3 | -0.2 | 0.1 | 0.0 | 0.0 | 0.02 | 0.0 | 5 | 2 | -9 | -14 | -1 | -13.4 |
| %error | 2.2 | 2.8 | 4.1 | 7.3 | 3.5 | 4.3 | 0.0 | 0.0 | 5 | 0.0 | 0.66 | 0.66 | 3.8 | 2.4 | 0.53 | 13.7 |
| | | | | | | | | | | | | | | | | |
| SARM 69 | 66.1 | 14.0 | 7.0 | 1.8 | 2.3 | 0.8 | 1.9 | 0.7 | 0.2 | 0.1 | 477 | 101 | 197 | 40.9 | 136 | 49.4 |
| SARM 69 K | 66.6 | 14.4 | 7.2 | 1.9 | 2.4 | 0.8 | 2 | 0.8 | 0.3 | 0.1 | 518 | 109 | 223 | 53 | 157 | 68 |
| error | -0.5 | -0.4 | -0.2 | -0.1 | -0.1 | 0.0 | -0.1 | -0.1 | -0.1 | 0.0 | -41 | -8 | -26 | -12.1 | -21 | -18.6 |
| %error | 0.8 | 2.8 | 2.8 | 5.3 | 4.2 | 0.0 | 5 | 12.5 | 33.4 | 0.0 | 7.9 | 7.3 | 11.7 | 22.8 | 13.4 | 27.4 |

*K = the known values for the standard

Table III.2: Assessment of accuracy in ICP-MS data

| Sample* | Sc | Cr | Co | Rb | Ce | Th |
|---|---|---|---|---|---|---|
| SARM 69 | 73.1 | 207 | 25.2 | 61.5 | 63.7 | 8.4 |
| SARM 69 K | 20 | 223 | 25 | 66 | 67 | 9 |
| error | 53.1 | -16 | 0.2 | -4.5 | -3.3 | -0.6 |
| %error | 266 | 7.2 | 0.8 | 6.8 | 4.9 | 6.6 |

*K = the known values for the standard

Table III.3: Assessment of precision from the analysis of powder from the same sherd sample, ICP-AES data

| Sample | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MgO | CaO | $Na_2O$ | $K_2O$ | $TiO_2$ | $P_2O_5$ | MnO | Ba | Sr | Cr | Ni | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 27.9 | 6.6 | 3.4 | 1.6 | 30 | 0.51 | 1.8 | 0.45 | 1.5 | 0.18 | 2834 | 569 | 131 | 71.6 | 110 | 96.9 |
| 7 rpt | 26.7 | 6.3 | 3.1 | 1.5 | 29.4 | 0.51 | 1.8 | 0.44 | 1.5 | 0.17 | 2917 | 577 | 128 | 58.9 | 91 | 85.4 |
| error | 1.2 | 0.3 | 0.3 | 0.1 | 0.6 | 0.0 | 0.0 | 0.01 | 0.0 | 0.01 | -83 | -8 | 3 | 12.7 | 19 | 11.5 |
| %error | 4.5 | 4.8 | 9.7 | 6.7 | 2 | 0.0 | 0.0 | 2.3 | 0.0 | 5.9 | 2.8 | 1.4 | 2.3 | 21.6 | 20.9 | 13.5 |
| | | | | | | | | | | | | | | | | |
| 17 | 33.8 | 7.7 | 4.3 | 1.3 | 20.3 | 0.43 | 1.2 | 0.63 | 0.21 | 0.06 | 222 | 291 | 119 | 63.3 | 81.9 | 52.2 |
| 17 rpt | 35.7 | 8.6 | 4.8 | 1.4 | 22.5 | 0.50 | 1.4 | 0.73 | 0.26 | 0.07 | 257 | 335 | 134 | 63.8 | 91.7 | 57.9 |
| error | -1.9 | -0.9 | -0.5 | -0.1 | -2.2 | -0.07 | -0.2 | -0.1 | -0.05 | -0.01 | -35 | -44 | -15 | -0.5 | -9.8 | -5.7 |
| %error | 5.3 | 10.5 | 10.4 | 7.1 | 9.7 | 14 | 14.3 | 13.7 | 19.2 | 14.3 | 13.6 | 13.1 | 11.2 | 0.78 | 10.7 | 9.8 |

Table III.4: Assessment of precision from the analysis of powder from the same sherd sample, ICP-MS data

| Sample | Sc | Cr | Co | Rb | Cs | La | Ce | Sm | Eu | Dy | Yb | Lu | Hf | Ta | Th | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 32.8 | 126 | 11.3 | 24.9 | 1.5 | 28.4 | 37.5 | 4.9 | 1.4 | 5.3 | 3.1 | 0.46 | 3.3 | 0.51 | 4.1 | 4.3 |
| 7 rpt | 32 | 122 | 10.7 | 24.6 | 1.3 | 27.9 | 36.6 | 5 | 1.5 | 5.3 | 3.2 | 0.45 | 3.2 | 0.48 | 3.9 | 4.4 |
| error | 0.8 | 4 | 0.6 | 0.3 | 0.2 | 0.5 | 0.9 | -0.1 | -0.1 | 0.0 | -0.1 | 0.01 | 0.1 | 0.03 | 0.2 | -0.1 |
| %error | 2.5 | 3.3 | 5.6 | 1.2 | 15.4 | 1.8 | 2.5 | 2 | 6.7 | 0.0 | 3.1 | 2.2 | 3.1 | 6.3 | 5.1 | 2.3 |
| | | | | | | | | | | | | | | | | |
| 17 | 44 | 141 | 16 | 22.5 | 1.4 | 19.4 | 42.5 | 4.4 | 1.1 | 3.7 | 1.8 | 0.25 | 3.4 | 0.82 | 5.1 | 1.8 |
| 17 rpt | 42.2 | 137 | 15.8 | 22.1 | 1.4 | 19.2 | 42.3 | 4.1 | 1.1 | 3.7 | 1.8 | 0.24 | 3.4 | 0.83 | 5.1 | 1.8 |
| error | 1.8 | 4 | 0.2 | 0.4 | 0.0 | 0.2 | 0.2 | 0.3 | 0.0 | 0.0 | 0.0 | 0.01 | 0.0 | 0.01 | 0.0 | 0.0 |
| %error | 4.3 | 2.9 | 1.3 | 1.8 | 0.0 | 1 | 0.47 | 7.3 | 0.0 | 0.0 | 0.0 | 4.2 | 0.0 | 1.2 | 0.0 | 0.0 |

Table III.5: Assessment of precision from the analysis of two samples from the same sherd, ICP-AES data

| Sample | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MgO | CaO | $Na_2O$ | $K_2O$ | $TiO_2$ | $P_2O_5$ | MnO | Ba | Sr | Cr | Ni | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 A | 44.2 | 7.5 | 3.9 | 1.2 | 12.8 | 0.39 | 1.6 | 0.63 | 0.23 | 0.05 | 1265 | 217 | 88.1 | 71.7 | 83.8 | 98.7 |
| 1 B | 44.6 | 7.7 | 4 | 1.3 | 12.7 | 0.36 | 1.5 | 0.58 | 0.2 | 0.04 | 955 | 193 | 95.4 | 50.8 | 76.9 | 63.8 |
| error | -0.4 | -0.2 | -0.1 | -0.1 | 0.1 | 0.03 | 0.1 | 0.05 | 0.03 | 0.01 | 310 | 24 | -7.3 | 20.9 | 6.9 | 34.9 |
| %error | 0.9 | 2.6 | 2.5 | 7.7 | 0.79 | 8.3 | 6.7 | 8.6 | 15 | 25 | 32.5 | 12.4 | 7.7 | 41.1 | 9 | 54.7 |
| | | | | | | | | | | | | | | | | |
| 5 A | 50.4 | 8.3 | 4.2 | 1.3 | 16 | 0.46 | 1.6 | 0.67 | 0.45 | 0.11 | 1211 | 226 | 95.4 | 68.4 | 92.4 | 77.9 |
| 5 B | 49.5 | 8 | 4.2 | 1.3 | 15.7 | 0.47 | 1.6 | 0.67 | 0.41 | 0.07 | 1746 | 242 | 108 | 68.2 | 89.8 | 79.2 |
| error | 0.9 | 0.3 | 0.0 | 0.0 | 0.3 | -0.01 | 0.0 | 0.0 | 0.04 | 0.04 | -535 | -16 | -12.6 | 0.2 | 2.6 | -1.3 |
| %error | 1.8 | 3.8 | 0.0 | 0.0 | 1.9 | 2.1 | 0.0 | 0.0 | 9.8 | 57.1 | 30.6 | 6.6 | 11.7 | 0.29 | 2.9 | 1.6 |
| | | | | | | | | | | | | | | | | |
| 9 A | 56.2 | 8.8 | 4.6 | 1.2 | 14.8 | 0.47 | 1.3 | 0.81 | 0.42 | 0.14 | 1760 | 274 | 114 | 72.3 | 108 | 73.6 |
| 9 B | 55.8 | 8.8 | 4.6 | 1.2 | 15.4 | 0.48 | 1.4 | 0.83 | 0.48 | 0.17 | 1662 | 272 | 109 | 64 | 118 | 72.8 |
| error | 0.4 | 0.0 | 0.0 | 0.0 | -0.6 | -0.01 | 0.1 | -0.02 | -0.06 | -0.03 | 98 | 2 | 5 | 8.3 | -10 | 0.8 |
| %error | 0.72 | 0.0 | 0.0 | 0.0 | 3.9 | 2.1 | 7.1 | 2.4 | 12.5 | 17.6 | 5.9 | 0.74 | 4.6 | 13 | 8.5 | 1.1 |
| | | | | | | | | | | | | | | | | |
| 13 A | 46.7 | 7.8 | 4 | 1.2 | 18.1 | 0.39 | 1.5 | 0.65 | 0.28 | 0.04 | 1290 | 289 | 99 | 63.3 | 83.1 | 66.8 |
| 13 B | 46.3 | 7.6 | 4 | 1.2 | 18.6 | 0.41 | 1.5 | 0.67 | 0.29 | 0.05 | 1682 | 295 | 100 | 66.4 | 95.7 | 68.5 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| error | 0.4 | 0.2 | 0.0 | 0.0 | -0.5 | -0.02 | 0.0 | -0.02 | -0.01 | -0.01 | -392 | -6 | -1 | -3.1 | -12.6 | -1.7 |
| %error | 0.86 | 2.6 | 0.0 | 0.0 | 2.7 | 4.9 | 0.0 | 3 | 3.4 | 20 | 23.3 | 2 | 1 | 4.7 | 13.2 | 2.5 |
| | | | | | | | | | | | | | | | | |
| 20 A | 45.6 | 9.4 | 5.1 | 1.2 | 19.1 | 0.55 | 1.7 | 0.91 | 0.33 | 0.10 | 354 | 460 | 95 | 43 | 102 | 59.3 |
| 20 B | 47.9 | 10 | 5.4 | 1.2 | 17.8 | 0.56 | 1.6 | 0.91 | 0.32 | 0.09 | 370 | 398 | 94.5 | 50.9 | 95.6 | 57.7 |
| error | -2.3 | -0.6 | -0.3 | 0.0 | 1.3 | -0.01 | 0.1 | 0.0 | 0.01 | 0.01 | -16 | 62 | 0.5 | -7.9 | 6.4 | 1.6 |
| %error | 4.8 | 6 | 5.6 | 0.0 | 7.3 | 1.8 | 6.3 | 0.0 | 3.1 | 11.1 | 4.3 | 15.6 | 0.53 | 15.5 | 6.7 | 2.8 |
| | | | | | | | | | | | | | | | | |
| 49 A | 26 | 7.2 | 5 | 2.7 | 27.1 | 0.58 | 1.7 | 0.77 | 0.25 | 0.10 | 213 | 682 | 104 | 62 | 91.2 | 51.3 |
| 49 B | 24.9 | 6.9 | 4.8 | 2.6 | 26.4 | 0.59 | 1.7 | 0.79 | 0.25 | 0.10 | 217 | 724 | 105 | 72.5 | 98.4 | 52.7 |
| error | 1.1 | 0.3 | 0.2 | 0.1 | 0.7 | -0.01 | 0.0 | -0.02 | 0.0 | 0.0 | -4 | -42 | -1 | -10.5 | -7.2 | -1.4 |
| %error | 4.4 | 4.3 | 4.2 | 3.8 | 2.7 | 1.7 | 0.0 | 2.5 | 0.0 | 0.0 | 1.8 | 5.8 | 0.95 | 14.5 | 7.3 | 2.7 |

Table III.6: Assessment of precision from the analysis of two samples from the same sherd, ICP-MS data

| Sample | Sc | Cr | Co | Rb | Cs | La | Ce | Sm | Eu | Dy | Yb | Lu | Hf | Ta | Th | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 A | 53.8 | 114 | 14.8 | 27 | 1.5 | 26.7 | 52.3 | 5.4 | 1.3 | 4.7 | 2.7 | 0.45 | 5.6 | 1.1 | 5.7 | 1.8 |
| 1 B | 56.2 | 123 | 13.7 | 27.7 | 1.5 | 28.2 | 53.4 | 5.4 | 1.5 | 5.3 | 2.8 | 0.43 | 5.4 | 1 | 6 | 1.8 |
| error | -2.4 | -9 | 1.1 | -0.7 | 0.0 | -1.5 | -1.1 | 0.0 | -0.2 | -0.6 | -0.1 | 0.02 | 0.2 | 0.1 | -0.3 | 0.0 |
| %error | 4.3 | 7.3 | 8 | 2.5 | 0.0 | 5.3 | 2.1 | 0.0 | 13.3 | 11.3 | 3.6 | 4.7 | 3.7 | 10 | 5 | 0.0 |
| | | | | | | | | | | | | | | | | |
| 5 A | 51.6 | 102 | 14.2 | 24.4 | 1.5 | 24 | 48.8 | 5 | 1.3 | 4.4 | 2.3 | 0.37 | 5.1 | 0.99 | 5.5 | 1.9 |
| 5 B | 51.9 | 107 | 13.1 | 24.5 | 1.2 | 25.5 | 46.5 | 4.9 | 1.4 | 4.6 | 2.5 | 0.36 | 4.8 | 0.9 | 5.3 | 1.8 |
| error | -0.3 | -5 | 1.1 | -0.1 | 0.3 | -1.5 | 2.3 | 0.01 | -0.1 | -0.2 | -0.2 | 0.01 | 0.3 | 0.09 | 0.2 | 0.1 |
| %error | 0.58 | 4.7 | 8.4 | 0.41 | 25 | 5.9 | 4.9 | 0.2 | 7.1 | 4.3 | 8 | 2.8 | 6.3 | 10 | 3.8 | 5.6 |
| | | | | | | | | | | | | | | | | |
| 9 A | 57.6 | 114 | 16.2 | 33.4 | 1.6 | 27.3 | 53.7 | 5.4 | 1.4 | 5.1 | 2.8 | 0.46 | 5.8 | 1.1 | 5.9 | 2.2 |
| 9 B | 56.7 | 114 | 16.9 | 32.4 | 1.5 | 27.3 | 54.1 | 5.4 | 1.4 | 5.1 | 2.9 | 0.38 | 5.3 | 1.0 | 5.9 | 2.2 |
| error | 0.9 | 0.0 | -0.7 | 1 | 0.1 | 0.0 | -0.4 | 0.0 | 0.0 | 0.0 | -0.1 | 0.08 | 0.5 | 0.1 | 0.0 | 0.0 |
| %error | 1.6 | 0.0 | -4.1 | 3.1 | 6.7 | 0.0 | 0.74 | 0.0 | 0.0 | 0.0 | 3.4 | 21.1 | 9.4 | 10 | 0.0 | 0.0 |
| | | | | | | | | | | | | | | | | |
| 13 A | 47.5 | 103 | 10.9 | 22.4 | 1.2 | 23.3 | 44.6 | 4.6 | 1.3 | 4.3 | 2.4 | 0.34 | 4.9 | 0.87 | 5 | 1.7 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 B | 46.1 | 96.6 | 11.2 | 21.6 | 1.1 | 22.9 | 43.5 | 4.5 | 1.2 | 4.2 | 2.3 | 0.37 | 4.3 | 0.84 | 4.8 | 1.7 |
| error | 1.4 | 6.4 | -0.3 | 0.8 | 0.1 | 0.4 | 1.1 | 0.1 | 0.1 | 0.1 | 0.1 | -0.03 | 0.6 | 0.03 | 0.2 | 0.0 |
| %error | 3 | 6.6 | 2.7 | 3.7 | 9.1 | 1.7 | 2.5 | 2.2 | 8.3 | 2.4 | 4.3 | 8.1 | 14 | 3.6 | 4.2 | 0.0 |
| | | | | | | | | | | | | | | | | |
| 20 A | 50.2 | 95.3 | 16.3 | 30.8 | 1.2 | 26 | 59.8 | 5.1 | 1.2 | 4.5 | 2.4 | 0.35 | 7.3 | 1.2 | 6.5 | 1.6 |
| 20 B | 54.7 | 108 | 17.7 | 33.2 | 1.4 | 27.1 | 61.7 | 5.4 | 1.3 | 4.6 | 2.6 | 0.37 | 8 | 1.3 | 6.6 | 1.7 |
| error | -4.5 | -12.7 | -1.4 | -2.4 | -0.2 | -1.1 | -1.9 | -0.3 | -0.1 | -0.1 | -0.2 | -0.02 | -0.7 | -0.1 | -0.1 | -0.1 |
| %error | 8.2 | 11.8 | 7.9 | 7.2 | 14.3 | 4.1 | 3.1 | 5.6 | 7.7 | 2.2 | 7.7 | 5.4 | 8.8 | 7.7 | 1.5 | 5.9 |
| | | | | | | | | | | | | | | | | |
| 49 A | 33.6 | 111 | 15.1 | 19.4 | 0.91 | 17 | 34.4 | 3.3 | 1 | 3.2 | 1.4 | 0.19 | 2.5 | 0.76 | 3.3 | 2.9 |
| 49 B | 33.8 | 106 | 15.1 | 21 | 1.1 | 17.3 | 35.1 | 3.7 | 1 | 3 | 1.4 | 0.22 | 2.5 | 0.86 | 3.4 | 3 |
| error | -0.2 | 5 | 0.0 | -1.6 | -0.19 | -0.3 | -0.7 | -0.4 | 0.0 | 0.2 | 0.0 | -0.03 | 0.0 | -0.1 | -0.1 | -0.1 |
| %error | 0.59 | 4.7 | 0.0 | 7.6 | 17.3 | 1.7 | 2 | 10.8 | 0.0 | 6.7 | 0.0 | 13.6 | 0.0 | 11.6 | 2.9 | 3.4 |

Table III.7: Raw Data from samples, ICP-AES data[232]

| Sample | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MgO | CaO | $Na_2O$ | $K_2O$ | $TiO_2$ | $P_2O_5$ | MnO | Ba | Sr | Cr | Ni | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ow 1A | 44.2 | 7.5 | 3.9 | 1.2 | 12.8 | 0.39 | 1.6 | 0.63 | 0.23 | 0.05 | 1265 | 217 | 88.1 | 71.7 | 83.8 | 98.7 |
| Ow 1B | 44.6 | 7.7 | 4 | 1.3 | 12.7 | 0.36 | 1.5 | 0.58 | 0.2 | 0.04 | 955 | 193 | 95.4 | 50.8 | 76.9 | 63.8 |
| Ow 2 | 35.2 | 7.5 | 4 | 1.6 | 17.4 | 0.31 | 1.3 | 0.57 | 0.33 | 0.05 | 366 | 348 | 72.6 | 39.3 | 73.7 | 72.5 |
| Ow 3 | 43.6 | 11 | 5.7 | 0.81 | 13.3 | 0.42 | 1.5 | 0.85 | 0.25 | 0.09 | 361 | 317 | 103 | 50.5 | 109 | 66.2 |
| Ow 4 | 46.5 | 8.6 | 4.4 | 0.79 | 11.3 | 0.46 | 1.6 | 0.66 | 0.41 | 0.05 | 244 | 154 | 75.8 | 36.7 | 93.7 | 57.7 |
| Ow 5A | 50.4 | 8.3 | 4.2 | 1.3 | 16 | 0.46 | 1.6 | 0.67 | 0.45 | 0.11 | 1212 | 226 | 95.4 | 68.5 | 92.4 | 77.9 |
| Ow 5B | 49.5 | 8 | 4.2 | 1.3 | 15.7 | 0.47 | 1.6 | 0.67 | 0.41 | 0.07 | 1746 | 242 | 108 | 68.2 | 89.8 | 79.2 |
| Ow 6 | 48.6 | 8 | 4.3 | 1.2 | 15 | 0.47 | 1.7 | 0.76 | 0.73 | 0.13 | 543 | 226 | 94.3 | 61.5 | 94.3 | 89.3 |
| Ow 7 | 27.9 | 6.6 | 3.4 | 1.6 | 30 | 0.51 | 1.8 | 0.45 | 1.5 | 0.18 | 2834 | 569 | 131 | 71.6 | 110 | 96.9 |
| Ow 7rpt | 26.7 | 6.3 | 3.1 | 1.6 | 29.4 | 0.51 | 1.8 | 0.44 | 1.5 | 0.17 | 2917 | 577 | 128 | 58.9 | 91 | 85.4 |
| Ow 8 | 48.2 | 6.8 | 3.5 | 1.1 | 18.3 | 0.46 | 1.4 | 0.62 | 0.29 | 0.05 | 1244 | 332 | 83.7 | 58.3 | 76.2 | 62.7 |
| Ow 9A | 56.2 | 8.8 | 4.6 | 1.2 | 14.8 | 0.47 | 1.3 | 0.81 | 0.42 | 0.14 | 1760 | 274 | 114 | 72.3 | 108 | 73.6 |
| Ow 9B | 55.8 | 8.8 | 4.6 | 1.2 | 15.4 | 0.48 | 1.4 | 0.83 | 0.48 | 0.17 | 1662 | 272 | 109 | 64 | 118 | 72.8 |

[232] Presentation of raw data follows the guidelines stated above. Raw data has been rounded for presentation only.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ow 10 | 58 | 9.8 | 5.1 | 1.5 | 8.3 | 0.47 | 1.9 | 0.87 | 0.34 | 0.08 | 1359 | 169 | 136 | 91.7 | 123 | 114 |
| Ow 11 | 53.8 | 9.2 | 4.8 | 1.3 | 7.2 | 0.66 | 1.2 | 0.79 | 0.14 | 0.09 | 372 | 162 | 73.7 | 40.6 | 92.8 | 78.8 |
| Ow 12 | 54.6 | 12.8 | 5.6 | 1.5 | 4.4 | 1.1 | 1.8 | 0.89 | 0.69 | 0.06 | 376 | 287 | 75.1 | 43.6 | 109 | 88.8 |
| Ow 13A | 46.7 | 7.8 | 4 | 1.2 | 18.1 | 0.39 | 1.5 | 0.65 | 0.28 | 0.04 | 1290 | 289 | 99 | 63.3 | 83.2 | 66.8 |
| Ow 13B | 46.3 | 7.6 | 4 | 1.2 | 18.6 | 0.41 | 1.5 | 0.67 | 0.29 | 0.05 | 1682 | 295 | 101 | 66.4 | 95.7 | 68.5 |
| Ow 14 | 49.8 | 6.9 | 3.6 | 1.2 | 15.9 | 0.37 | 1.4 | 0.51 | 0.36 | 0.11 | 1062 | 187 | 66.6 | 48.1 | 71.5 | 69.7 |
| Ow 15 | 30 | 7.4 | 3.9 | 1.3 | 30.5 | 0.4 | 1.2 | 0.56 | 0.61 | 0.06 | 1760 | 422 | 144 | 84.9 | 88 | 118 |
| Ow 16 | 39 | 10.1 | 5.7 | 1.6 | 21.9 | 0.54 | 1 | 0.88 | 0.39 | 0.1 | 202 | 313 | 142 | 63.6 | 120 | 75.8 |
| Ow 17 | 33.8 | 7.7 | 4.3 | 1.3 | 20.3 | 0.43 | 1.2 | 0.63 | 0.21 | 0.06 | 222 | 291 | 119 | 63.3 | 81.9 | 52.2 |
| Ow 17rpt | 35.7 | 8.6 | 4.8 | 1.4 | 22.5 | 0.5 | 1.4 | 0.73 | 0.26 | 0.07 | 257 | 335 | 134 | 63.8 | 91.7 | 57.9 |
| Ow 18 | 48.9 | 7.7 | 4 | 1.1 | 16.2 | 0.47 | 1.6 | 0.62 | 0.41 | 0.06 | 1442 | 256 | 102 | 65.7 | 82.7 | 70 |
| Ow 19 | 46.2 | 11 | 6.2 | 1.5 | 15.5 | 0.61 | 1.4 | 0.93 | 0.28 | 0.08 | 281 | 278 | 168 | 98.7 | 120 | 80.3 |
| Ow 20A | 45.7 | 9.4 | 5.1 | 1.2 | 19.1 | 0.55 | 1.7 | 0.91 | 0.33 | 0.1 | 354 | 461 | 95 | 43 | 102 | 59.3 |
| Ow 20B | 47.9 | 10 | 5.4 | 1.2 | 17.8 | 0.56 | 1.6 | 0.91 | 0.32 | 0.09 | 370 | 398 | 94.5 | 50.9 | 95.6 | 57.7 |
| Ow 21 | 37.6 | 8.8 | 5 | 1.3 | 20.2 | 0.45 | 1.5 | 0.72 | 0.60 | 0.07 | 448 | 314 | 106 | 47.6 | 93.1 | 77.7 |
| Ow 22 | 60.2 | 11.1 | 5.7 | 0.97 | 7.5 | 0.58 | 2.1 | 0.87 | 0.32 | 0.09 | 408 | 145 | 94.7 | 47.6 | 107 | 109 |
| Ow 23 | 30.4 | 6.2 | 3.5 | 1.5 | 20 | 0.3 | 1.1 | 0.55 | 0.44 | 0.05 | 478 | 400 | 73.9 | 38.1 | 77 | 76.9 |
| Ow 24 | 50.9 | 9.5 | 4.9 | 0.84 | 13.3 | 0.5 | 1.8 | 0.77 | 0.44 | 0.18 | 410 | 191 | 93.2 | 51.2 | 107 | 62.2 |
| Ow 25 | 47.4 | 16 | 7.5 | 2.2 | 11 | 2 | 1.6 | 1.2 | 0.45 | 0.07 | 323 | 474 | 137 | 49.7 | 161 | 98.7 |
| Ow 26 | 35.4 | 7.7 | 4.3 | 1.4 | 22.1 | 0.68 | 1.8 | 0.73 | 0.62 | 0.09 | 427 | 340 | 90 | 54.9 | 82.4 | 57.4 |
| Ow 27 | 48.2 | 13.3 | 6.8 | 2.3 | 10.4 | 0.52 | 2 | 1.2 | 0.28 | 0.09 | 340 | 141 | 119 | 63.8 | 118 | 62.6 |
| Ow 33 | 35.7 | 8 | 4.6 | 1 | 21.2 | 0.43 | 1.4 | 0.74 | 0.29 | 0.09 | 226 | 233 | 89.8 | 47.2 | 88 | 60.6 |
| Ow 35 | 34 | 6.6 | 3.7 | 1.4 | 18.7 | 0.44 | 1.5 | 0.62 | 0.93 | 0.07 | 590 | 349 | 108 | 61.6 | 84.4 | 66.4 |
| Ow 37 | 36 | 6.7 | 3.6 | 0.99 | 16.7 | 0.63 | 1.4 | 0.55 | 0.25 | 0.08 | 356 | 298 | 51.6 | 34.2 | 70.9 | 46.4 |
| Ow 42 | 39.8 | 8.3 | 4.4 | 1.3 | 19.5 | 0.59 | 1.9 | 0.75 | 0.68 | 0.11 | 347 | 345 | 121 | 60.8 | 91.4 | 81.1 |
| Ow 45 | 48.5 | 9.7 | 4.9 | 0.93 | 13.6 | 0.65 | 1.8 | 0.78 | 0.61 | 0.08 | 302 | 226 | 86.7 | 23.1 | 102 | 63.9 |
| Ow 49A | 26.1 | 7.2 | 5 | 2.7 | 27.1 | 0.58 | 1.7 | 0.77 | 0.25 | 0.1 | 213 | 682 | 104 | 62 | 91.2 | 51.4 |
| Ow 49B | 24.9 | 6.9 | 4.8 | 2.6 | 26.4 | 0.59 | 1.7 | 0.79 | 0.25 | 0.1 | 217 | 724 | 105 | 72.5 | 98.4 | 52.7 |
| Ow 50 | 49.3 | 9.7 | 4.9 | 0.97 | 13.9 | 0.68 | 2 | 0.81 | 0.61 | 0.08 | 361 | 255 | 96 | 43.9 | 106 | 68.3 |
| Ow 51 | 37.5 | 9.8 | 5.5 | 1.4 | 20.1 | 0.68 | 1.7 | 0.86 | 0.59 | 0.12 | 364 | 399 | 139 | 82 | 125 | 65.3 |
| Ow 52 | 34.6 | 8.2 | 4.6 | 1.3 | 16.2 | 0.48 | 1.2 | 0.72 | 0.31 | 0.07 | 221 | 245 | 128 | 69.4 | 90.3 | 49.6 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ow 53 | 23.4 | 6.3 | 4.4 | 2.8 | 30.2 | 0.55 | 1.7 | 0.67 | 0.36 | 0.04 | 149 | 565 | 105 | 57.3 | 74.1 | 53.4 |
| Ow 54 | 36.1 | 8.5 | 4.7 | 1.3 | 23.5 | 0.49 | 1.4 | 0.71 | 0.27 | 0.08 | 242 | 314 | 127 | 68.5 | 89.2 | 53.2 |
| Ow 55 | 32.3 | 7.3 | 4 | 1.3 | 25.9 | 0.45 | 1.4 | 0.62 | 0.56 | 0.09 | 466 | 361 | 83.9 | 37.59 | 69.3 | 85 |
| Ow 56 | 25.1 | 7.7 | 5 | 1.6 | 30.6 | 0.33 | 1.1 | 0.74 | 0.17 | 0.08 | 263 | 591 | 84.6 | 50 | 92.4 | 37.2 |

Table III.8: Raw Data from samples, ICP-MS data

| Sample | Sc | Cr | Co | Rb | Cs | La | Ce | Sm | Eu | Dy | Yb | Lu | Hf | Ta | Th | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ow 1A | 53.8 | 114 | 14.8 | 27 | 1.5 | 26.7 | 52.3 | 5.4 | 1.3 | 4.7 | 2.7 | 0.45 | 5.6 | 1.1 | 5.7 | 1.8 |
| Ow 1B | 56.2 | 123 | 13.7 | 27.7 | 1.5 | 28.2 | 53.4 | 5.4 | 1.5 | 5.3 | 2.8 | 0.43 | 5.4 | 1 | 6 | 1.8 |
| Ow 2 | 45.6 | 112 | 13.1 | 30.8 | 1.5 | 27.4 | 54.6 | 5.3 | 1.3 | 4.9 | 2.5 | 0.34 | 5.9 | 0.98 | 5.8 | 2 |
| Ow 3 | 56.6 | 130 | 21.7 | 35.4 | 1.5 | 37.6 | 85.3 | 7.6 | 1.7 | 6.6 | 3.1 | 0.49 | 7.5 | 1.6 | 8.8 | 2.3 |
| Ow 4 | 56.7 | 95 | 10.8 | 32 | 1.9 | 23.1 | 52.9 | 4.6 | 1.1 | 4.1 | 2.2 | 0.33 | 4.3 | 1 | 6.5 | 1.7 |
| Ow 5A | 51.6 | 102 | 14.2 | 24.4 | 1.5 | 24 | 48.8 | 5 | 1.3 | 4.4 | 2.3 | 0.37 | 5.1 | 0.99 | 5.5 | 1.9 |
| Ow 5B | 51.9 | 107 | 13.1 | 24.5 | 1.3 | 25.5 | 46.5 | 4.9 | 1.4 | 4.6 | 2.5 | 0.36 | 4.8 | 0.90 | 5.3 | 1.8 |
| Ow 6 | 52 | 101 | 17.2 | 25.9 | 1.3 | 24.4 | 46.4 | 4.9 | 1.2 | 4.6 | 2.7 | 0.4 | 5 | 0.97 | 5.5 | 2.5 |
| Ow 7 | 32.8 | 126 | 11.3 | 24.9 | 1.5 | 28.4 | 37.5 | 4.9 | 1.4 | 5.3 | 3.1 | 0.46 | 3.3 | 0.51 | 4.1 | 4.3 |
| Ow 7rpt | 32 | 122 | 10.7 | 24.6 | 1.3 | 27.9 | 36.6 | 5 | 1.5 | 5.3 | 3.2 | 0.45 | 3.2 | 0.48 | 3.9 | 4.4 |
| Ow 8 | 48.7 | 85.4 | 10.9 | 21.7 | 1.2 | 22.5 | 41.1 | 4.1 | 1.2 | 3.8 | 2.2 | 0.32 | 4.5 | 0.89 | 4.5 | 1.4 |
| Ow 9A | 57.6 | 114 | 16.2 | 33.4 | 1.6 | 27.3 | 53.7 | 5.4 | 1.4 | 5.1 | 2.8 | 0.46 | 5.8 | 1.1 | 5.9 | 2.2 |
| Ow 9B | 56.7 | 114 | 16.9 | 32.4 | 1.5 | 27.3 | 54.1 | 5.4 | 1.4 | 5.1 | 2.9 | 0.38 | 5.3 | 1.1 | 5.9 | 2.2 |
| Ow 10 | 61.2 | 143 | 18.2 | 32.3 | 1.7 | 29.6 | 61.2 | 6.2 | 1.6 | 5.5 | 3.1 | 0.44 | 5.7 | 1.1 | 6.8 | 2.1 |
| Ow 11 | 62.9 | 89.6 | 17.9 | 38.4 | 1.7 | 27.3 | 59.9 | 5.8 | 1.4 | 5 | 2.8 | 0.37 | 5.1 | 1.2 | 6.6 | 1.4 |
| Ow 12 | 54.9 | 80.4 | 12.6 | 27.3 | 1.1 | 25.3 | 52.5 | 4.9 | 1.3 | 3.7 | 1.9 | 0.3 | 7.9 | 1.2 | 5.9 | 1.5 |
| Ow 13A | 47.5 | 103 | 10.9 | 22.4 | 1.2 | 23.3 | 44.6 | 4.6 | 1.3 | 4.3 | 2.4 | 0.34 | 4.9 | 0.87 | 5 | 1.7 |
| Ow 13B | 46.1 | 96.6 | 11.2 | 21.6 | 1.1 | 22.9 | 43.5 | 4.5 | 1.2 | 4.2 | 2.3 | 0.37 | 4.3 | 0.84 | 4.8 | 1.7 |
| Ow 14 | 47 | 71.7 | 11.9 | 20.7 | 1.1 | 17.3 | 37 | 3.9 | 0.94 | 3.4 | 1.8 | 0.3 | 3.6 | 0.75 | 4.1 | 1.3 |
| Ow 15 | 32.9 | 139 | 13.8 | 15.2 | 1.1 | 21.6 | 35.6 | 4 | 1.2 | 3.7 | 2.2 | 0.32 | 2.8 | 0.45 | 3.6 | 2.5 |
| Ow 16 | 43.8 | 143 | 17.6 | 33.4 | 2.6 | 25.8 | 49.6 | 4.8 | 1.2 | 4.2 | 2.3 | 0.32 | 3.9 | 1 | 5.9 | 2.1 |
| Ow 17 | 44 | 141 | 16 | 22.5 | 1.4 | 19.4 | 42.5 | 4.4 | 1.1 | 3.7 | 1.8 | 0.25 | 3.4 | 0.82 | 5.1 | 1.8 |
| Ow 17rpt | 42.2 | 138 | 15.8 | 22.1 | 1.4 | 19.2 | 42.3 | 4.1 | 1.1 | 3.7 | 1.8 | 0.24 | 3.4 | 0.83 | 5.1 | 1.8 |
| Ow 18 | 53.5 | 109 | 12.4 | 23.3 | 1.1 | 23 | 44.4 | 4.7 | 1.4 | 4.4 | 2.5 | 0.37 | 4.5 | 0.85 | 5 | 2.1 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ow 19 | 55.8 | 176 | 22.3 | 28.8 | 1.9 | 25.2 | 54.6 | 5 | 1.3 | 4.4 | 2.4 | 0.36 | 4.3 | 1.1 | 6.6 | 2 |
| Ow 20A | 50.2 | 95.3 | 16.3 | 30.8 | 1.2 | 26 | 59.8 | 5.1 | 1.2 | 4.5 | 2.4 | 0.35 | 7.3 | 1.2 | 6.5 | 1.6 |
| Ow 20B | 54.7 | 108 | 17.7 | 33.2 | 1.4 | 27.1 | 61.7 | 5.4 | 1.3 | 4.6 | 2.6 | 0.37 | 8 | 1.3 | 6.6 | 1.7 |
| Ow 21 | 45.7 | 125 | 16.3 | 26.3 | 1.2 | 29.7 | 57.7 | 6.1 | 1.6 | 5.5 | 3.1 | 0.47 | 6.6 | 0.98 | 6.3 | 2.5 |
| Ow 22 | 60.7 | 98.8 | 14.7 | 36.5 | 2.3 | 22.3 | 55.9 | 4.8 | 1.1 | 3.9 | 2 | 0.31 | 4.6 | 1.2 | 7.1 | 1.9 |
| Ow 23 | 42.2 | 100 | 13.2 | 20.9 | 1.1 | 22.5 | 43 | 4.5 | 1.1 | 4.1 | 2.3 | 0.34 | 4.9 | 0.77 | 5.1 | 2.4 |
| Ow 24 | 55.2 | 95.8 | 17.4 | 30 | 1.7 | 25.4 | 54.3 | 4.9 | 1.2 | 4.2 | 2.2 | 0.33 | 4.5 | 1.1 | 6.9 | 1.9 |
| Ow 25 | 65.5 | 138 | 17.5 | 43.1 | 2.1 | 45 | 93.6 | 8.7 | 2.2 | 7.8 | 3.7 | 0.54 | 6.5 | 2.1 | 8.6 | 3.2 |
| Ow 26 | 39.4 | 105 | 14.9 | 24.8 | 1 | 24 | 48.6 | 5 | 1.2 | 4.6 | 2.5 | 0.38 | 5.9 | 0.95 | 5.6 | 2.3 |
| Ow 27 | 61.4 | 134 | 20.4 | 60.9 | 4 | 33.5 | 79.6 | 7 | 1.6 | 5.7 | 3.2 | 0.43 | 7.6 | 1.7 | 10.2 | 2.2 |
| Ow 33 | 40.6 | 93.1 | 15.8 | 19.4 | 1.3 | 22.7 | 49.9 | 4.1 | 1.2 | 3.7 | 2.3 | 0.34 | 5.5 | 0.87 | 5.5 | 1.7 |
| Ow 35 | 40.8 | 135 | 13.2 | 20.4 | 0.87 | 30.6 | 52.6 | 5.5 | 1.3 | 4.9 | 2.6 | 0.44 | 6.1 | 0.80 | 5.5 | 3 |
| Ow 37 | 42.7 | 64.9 | 12.6 | 23.6 | 0.83 | 22.1 | 44.8 | 4.9 | 1.0 | 3.7 | 1.8 | 0.27 | 4.3 | 0.86 | 5 | 1.2 |
| Ow 42 | 44.8 | 128 | 14.6 | 22.5 | 0.92 | 27.6 | 51.7 | 5.5 | 1.3 | 4.8 | 2.6 | 0.4 | 4.8 | 0.91 | 5.2 | 4.2 |
| Ow 45 | 55.4 | 98.7 | 15.6 | 34.3 | 2.2 | 24.8 | 53.8 | 4.7 | 1.1 | 3.7 | 2.1 | 0.3 | 4.6 | 1.1 | 6.8 | 1.9 |
| Ow 49A | 33.6 | 111 | 15.1 | 19.4 | 0.91 | 17 | 34.4 | 3.3 | 1.0 | 3.2 | 1.4 | 0.18 | 2.5 | 0.76 | 3.3 | 2.9 |
| Ow 49B | 33.8 | 106 | 15.1 | 21 | 1.2 | 17.3 | 35.1 | 3.7 | 1.0 | 3 | 1.4 | 0.22 | 2.5 | 0.86 | 3.4 | 3 |
| Ow 50 | 51.6 | 98.5 | 14.2 | 31.2 | 1.8 | 23.9 | 52.7 | 4.7 | 1.1 | 3.9 | 1.9 | 0.35 | 4.7 | 1 | 6.6 | 1.9 |
| Ow 51 | 45.5 | 144 | 18 | 23.8 | 1.4 | 21.9 | 45.6 | 4.3 | 1.1 | 3.9 | 2 | 0.3 | 3.5 | 0.91 | 5.3 | 2 |
| Ow 52 | 45.9 | 149 | 17.3 | 27.4 | 1.7 | 21.3 | 46.3 | 4.8 | 1.1 | 4.1 | 2 | 0.31 | 3.4 | 0.92 | 5.5 | 1.8 |
| Ow 53 | 29.4 | 106 | 12.4 | 22.3 | 1.3 | 15.2 | 29.5 | 3.1 | 0.74 | 2.6 | 1.1 | 0.21 | 2.2 | 0.65 | 3 | 2.7 |
| Ow 54 | 41.7 | 135 | 15.1 | 22.9 | 1.4 | 19.8 | 43.5 | 3.8 | 1.0 | 3.5 | 1.7 | 0.28 | 3.6 | 0.84 | 5.1 | 1.7 |
| Ow 55 | 37.9 | 104 | 15.2 | 21.9 | 0.97 | 27 | 52.9 | 5.4 | 1.3 | 4.9 | 2.7 | 0.42 | 5.5 | 0.79 | 5.6 | 2.5 |
| Ow 56 | 30.8 | 100 | 13.8 | 18 | 0.97 | 20.8 | 46.2 | 4.4 | 1.2 | 3.5 | 1.7 | 0.27 | 3.5 | 0.81 | 4.5 | 2.5 |

Table III.9: Raw Data from samples, NAA data

| **Sample** | **$Al_2O_3$** | **$Fe_2O_3$** | **CaO** | **$Na_2O$** | **$K_2O$** | **$TiO_2$** | **Mn** | **V** | **Cr** | **Sc** | **Co** | **Rb** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ow 28 | 4.4 | 2.7 | 19.1 | 0.39 | 1.4 | 0.4 | 524 | 75.5 | 74.6 | 8.9 | 11.4 | 37.9 |
| Ow 29 | 4 | 2.9 | 20.4 | 0.4 | 1.8 | 0.43 | 793 | 83.1 | 109 | 9.7 | 14.7 | 29.4 |
| Ow 30 | 5.5 | 4.3 | 16.7 | 0.34 | 1.5 | 0.56 | 770 | 122 | 161 | 13.9 | 19.5 | 44 |
| Ow 31 | 4.4 | 3.8 | 16.7 | 0.23 | 1.1 | 0.47 | 1086 | 90.2 | 131 | 12.7 | 18.2 | 34.3 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ow 32 | 4.7 | 3.5 | 19.8 | 0.21 | 1.5 | 0.34 | 875 | 91.8 | 125 | 11 | 13.4 | 21.1 |
| Ow 33 | 4.3 | 3.6 | 17.3 | 0.3 | 1.8 | 0.46 | 721 | 77.5 | 129 | 10.9 | 16.3 | 33.4 |
| Ow 34 | 4.5 | 3.4 | 21.7 | 0.18 | 1.8 | 0.34 | 480 | 88.3 | 110 | 11.1 | 13.2 | 38.1 |
| Ow 35A | 4.5 | 3.4 | 16.1 | 0.34 | 1.7 | 0.44 | 851 | 88.1 | 158 | 11.8 | 16 | 25.8 |
| Ow 35B | 4.1 | 3.3 | 15.3 | 0.28 | 1.7 | 0.44 | 1148 | 94.3 | 164 | 11.6 | 15.7 | 21.8 |
| Ow 36 | 4 | 3.1 | 11.9 | 0.28 | 1.7 | 0.38 | 666 | 76.5 | 120 | 11.4 | 14.8 | 23.5 |
| Ow 37 | 4.3 | 3.4 | 14 | 0.5 | 1.9 | 0.43 | 1002 | 73.9 | 82 | 10.8 | 19 | 22.2 |
| Ow 38A | 8 | 4.3 | 9.9 | 0.33 | 2.9 | 0.46 | 2115 | 141 | 152 | 15.6 | 20.6 | 70.1 |
| Ow 38B | 8.4 | 4.4 | 11.3 | 0.34 | 2.7 | 0.51 | 349 | 135 | 158 | 15.5 | 15.2 | 61.3 |
| Ow 39 | 5.2 | 3.3 | 12.8 | 0.31 | 1.8 | 0.43 | 549 | 84 | 91.1 | 10.7 | 13.1 | 31.5 |
| Ow 40 | 4.2 | 3.4 | 22.6 | 0.23 | 1.7 | 0.3 | 373 | 81.2 | 109 | 9.9 | 11.4 | 13.1 |
| Ow 41 | 5.7 | 3.7 | 9.2 | 0.3 | 1.7 | 0.54 | 932 | 99.4 | 112 | 12.8 | 17.2 | 29.4 |
| Ow 42 | 5 | 3.7 | 14.9 | 0.42 | 2.2 | 0.47 | 1049 | 88.8 | 149 | 12.4 | 18.9 | 34.2 |
| Ow 43 | 4.8 | 3.3 | 15.9 | 0.34 | 1.5 | 0.44 | 743 | 82.3 | 134 | 11.4 | 16.7 | 33.1 |
| Ow 44 | 4.9 | 3.5 | 16.4 | 0.28 | 1.7 | 0.5 | 671 | 86 | 104 | 11 | 15.7 | 16 |
| Ow 45 | 5.8 | 4.1 | 10.7 | 0.51 | 1.7 | 0.54 | 809 | 97.8 | 128 | 13.4 | 19.1 | 40.6 |
| Ow 46 | 7.9 | 5.7 | 7.7 | 0.31 | 2.3 | 0.85 | 1070 | 135 | 151 | 18.7 | 25.8 | 94 |
| Ow 47 | 8.9 | 5.6 | 8.2 | 0.76 | 1.4 | 0.7 | 640 | 163 | 143 | 22.1 | 25.1 | 62.3 |
| Ow 48 | 5.2 | 4.1 | 10.5 | 0.8 | 1.6 | 0.56 | 662 | 94.6 | 112 | 13.1 | 16.2 | 46.7 |
| Ow 49 | 3.6 | 3.8 | 20.4 | 0.4 | 1.5 | 0.44 | 606 | 78.4 | 151 | 10.9 | 16.8 | 14.3 |

Table III.10: Raw Data from samples, NAA data

| Sample | Cs | La | Ce | Sm | Eu | Dy | Yb | Lu | Hf | Ta | Th | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ow 28 | 2.5 | 19.2 | 39.7 | 3.5 | 0.95 | 3.4 | 1.6 | 0.25 | 4 | 0.94 | 5.3 | 2.2 |
| Ow 29 | 2.2 | 27.3 | 46.1 | 5.1 | 1.2 | 5.1 | 2.4 | 0.41 | 5.3 | 0.56 | 5.8 | 3.9 |
| Ow 30 | 3.1 | 26.8 | 50.1 | 4.9 | 1.5 | 4.5 | 2.2 | 0.38 | 4.2 | 1.2 | 6.4 | 2.8 |
| Ow 31 | 3.1 | 39.3 | 57.5 | 6.6 | 1.6 | 5.5 | 2.8 | 0.49 | 6.4 | 0.78 | 7.5 | 4 |
| Ow 32 | 2.7 | 19.3 | 33.5 | 3.8 | 1.2 | 3.3 | 2.2 | 0.27 | 3.1 | 0.9 | 5.3 | 3.7 |
| Ow 33 | 1.7 | 23.3 | 53.1 | 4.7 | 1.3 | 4.1 | 2.2 | 0.31 | 6 | 0.89 | 6 | 3.3 |
| Ow 34 | 2.4 | 20.5 | 34 | 3.7 | 0.93 | 2.9 | 2.2 | 0.35 | 2.8 | 1.7 | 5 | 2.6 |
| Ow 35A | 1.6 | 36.8 | 58.7 | 6.6 | 1.5 | 5.8 | 2.7 | 0.40 | 7.7 | 0.88 | 6.6 | 3.8 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ow 35B | 2.8 | 33.9 | 60.6 | 5.9 | 1.5 | 5.3 | 2.8 | 0.47 | 6.7 | 1.1 | 6.6 | 4.6 |
| Ow 36 | 2.5 | 26.1 | 49.6 | 5 | 1.2 | 4.9 | 3.7 | 0.28 | 5.5 | 0.47 | 5.6 | 3.3 |
| Ow 37 | 1.6 | 28.3 | 54.2 | 5 | 1.2 | 4.3 | 2.1 | 0.43 | 5.2 | 0.83 | 5.4 | 4 |
| Ow 38A | 4.7 | 41.7 | 80 | 8 | 1.6 | 5.5 | 3.4 | 0.42 | 5.2 | 1.4 | 11.1 | 8.2 |
| Ow 38B | 4.8 | 41.5 | 82.3 | 7.3 | 1.6 | 6.7 | 2.7 | 0.45 | 4.5 | 1.5 | 11.4 | 3.3 |
| Ow 39 | 3.2 | 21.8 | 46.1 | 4.4 | 0.98 | 3.8 | 2.4 | 0.36 | 3.8 | 1.2 | 6.6 | 2.1 |
| Ow 40 | 2 | 16.3 | 31.3 | 3.2 | 1 | 2.9 | 1 | 0.16 | 3.1 | 0.22 | 5 | 2.3 |
| Ow 41 | 3.4 | 39.7 | 63.9 | 7.8 | 1.7 | 7.4 | 4.3 | 0.50 | 6.4 | 2.5 | 7.2 | 2.9 |
| Ow 42 | 2.5 | 31.4 | 61.4 | 6.1 | 1.3 | 3.3 | 3.5 | 0.44 | 5.7 | 0.63 | 5.6 | 4.5 |
| Ow 43 | 2.9 | 26.8 | 55 | 5.3 | 1.6 | 3.5 | 3 | 0.45 | 5 | 0.77 | 4.8 | 3.7 |
| Ow 44 | 2.2 | 24.4 | 49.7 | 4.8 | 1.2 | 3.8 | 1.7 | 0.37 | 5.7 | 1.7 | 5.9 | 2.9 |
| Ow 45 | 3.1 | 28.1 | 61.2 | 5 | 1.3 | 2.7 | 2 | 0.37 | 5.7 | 0.95 | 7.7 | 2.7 |
| Ow 46 | 5.6 | 34.6 | 83.4 | 6.4 | 1.5 | 5.8 | 3 | 0.47 | 8.7 | 1.9 | 11.5 | 3.9 |
| Ow 47 | 3.5 | 43.9 | 83.7 | 8.4 | 1.7 | 6.7 | 2.7 | 0.49 | 6.7 | 2.2 | 9.9 | 3.9 |
| Ow 48 | 2.3 | 26.8 | 54.6 | 5.5 | 1.4 | 4.5 | 2.5 | 0.46 | 7.3 | 1.7 | 6.7 | 3.7 |
| Ow 49 | 2 | 18.5 | 30.6 | 3.8 | 1.3 | 2.7 | 1.6 | 0.27 | 2.9 | 1.1 | 3 | 3.4 |

# Appendix IV: Point Count Data

*See Appendix II, Table II.1 for abbreviations; alternative abbreviations used for the point counting include: CH= replacement and radiolarian chert; MAT= matrix

| TS # | QTZ | QIT | KF | PLG | LIM | CAL | KUK | MF | SH | FOX | OP | CP | AM | CHA | CH | PY | SP | VRF | MAT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ow 1 | 28 | 2 | | | 16 | | | | | | 2 | 11 | | | 1 | | | | 140 |
| Ow 2 | 17 | 1 | | | 37 | | | | | 1 | 5 | 3 | | | 4 | | | | 132 |
| Ow 3 | 20 | 1 | | | 5 | 1 | | 1 | | 2 | 2 | 10 | | | | | | | 158 |
| Ow 4 | 10 | | | | 21 | 2 | | | | | 5 | 2 | | | 16 | | | | 144 |
| Ow 5 | 33 | 1 | 1 | | 17 | | | 1 | | 1 | 2 | 2 | | | | 1 | | | 141 |
| Ow 6 | 27 | 1 | | | 21 | | | | | | | 2 | | | 1 | | | | 148 |
| Ow 7 | 5 | | | | 43 | | | | | 1 | 2 | 4 | | | | | | | 145 |
| Ow 8 | 19 | 3 | 1 | 1 | 30 | | | 3 | | 1 | | 2 | | | | | | | 140 |
| Ow 9 | 28 | 2 | | | 23 | | | | | 2 | 1 | | | | | 1 | | | 143 |
| Ow 10 | 25 | 1 | 1 | | 20 | | | 1 | | 1 | | | | | 1 | | | | 150 |
| Ow 11 | 33 | 2 | 2 | | 6 | | | | | 2 | | | | | | | | | 155 |
| Ow 12 | 29 | 4 | 2 | | 16 | 3 | | | | 3 | 1 | 4 | 1 | | | 1 | 2 | | 134 |
| Ow 13 | 25 | 1 | | | 22 | 3 | 3 | 1 | | 1 | | | | | | | | | 144 |
| Ow 14 | 41 | 1 | | | 24 | 1 | 4 | 1 | | 3 | | | | | | | | | 125 |
| Ow 15 | 4 | | | | 38 | | | | | 1 | | 3 | | | 1 | | | | 153 |
| Ow 16 | 1 | 1 | | | 23 | | | 2 | | 3 | 3 | 5 | | 2 | 5 | | | 11 | 144 |
| Ow 17 | | | | | 10 | 3 | | 2 | | 6 | 1 | | | | 6 | | | 14 | 158 |
| Ow 18 | 24 | | 1 | | 16 | | | | | 1 | | | | | | | 1 | | 157 |
| Ow 19 | 1 | | | | 14 | 1 | | 1 | | 10 | | 4 | | 1 | 8 | | | 22 | 138 |
| Ow 20 | 12 | 1 | | | 27 | | 2 | | | | 2 | 1 | | | | | | | 155 |
| Ow 21 | 12 | | | | 34 | | | | 2 | 1 | 1 | | | | 2 | | | | 148 |
| Ow 22 | 8 | | | | 31 | | | | | 1 | | | | 2 | 3 | | | | 155 |
| Ow 23 | 15 | | | | 32 | 4 | | | | 2 | 1 | | | | 5 | | | | 141 |
| Ow 24 | 7 | | | | 38 | | | | | 1 | 2 | | | | 11 | | | | 141 |
| Ow 25 | 11 | | | | 11 | | | | | | 2 | 4 | | | | | | | 172 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ow 26 | 2 | | | | 31 | 1 | | | | 3 | 1 | 2 | | | 3 | | | | 157 |
| Ow 27 | 2 | | | | 14 | | | | | 3 | 1 | 3 | | | | | | | 177 |
| Ow 28 | 9 | 8 | | | 35 | 1 | | | | | 2 | | | | 8 | | | | 137 |
| Ow 29 | 4 | | | | 41 | | | | | 1 | 1 | | | | 4 | | | | 149 |
| Ow 30 | 3 | | | | 19 | | | 1 | 3 | | | 3 | | 1 | 8 | | | 19 | 143 |
| Ow 31 | 12 | | 1 | | 32 | | | 1 | | 1 | 3 | 6 | | | 3 | | | | 141 |
| Ow 32 | 4 | 1 | | | 47 | | | 1 | | 3 | 3 | 1 | | | 9 | 1 | 2 | | 128 |
| Ow 33 | 15 | | | | 30 | | | | | 2 | 2 | 5 | | | | | | | 146 |
| Ow 34 | 3 | 1 | | | 48 | | | | | 4 | 1 | | | | 7 | | 2 | | 134 |
| Ow 35 | 3 | 1 | | | 23 | 1 | | | | 1 | 6 | | | | 17 | | | | 148 |
| Ow 36 | 16 | 1 | | | 20 | | | | | 1 | | 3 | | | 2 | | | | 157 |
| Ow 37 | 22 | 1 | | | 40 | | | | | | | | | | | 1 | | | 136 |
| Ow 38 | 4 | | | | 5 | | | | | 4 | 7 | 3 | | | | | | | 177 |
| Ow 39 | 8 | 1 | | | 41 | | | | | 2 | | | | | 14 | | | | 134 |
| Ow 40 | 2 | 1 | | | 45 | 1 | | 2 | | 6 | | | | | 4 | | | | 139 |
| Ow 41 | 19 | 2 | | | 25 | | | | | 2 | 1 | 4 | | | | | 1 | | 146 |
| Ow 42 | 20 | 2 | | | 32 | 1 | | | | 2 | | | | | 1 | | | | 142 |
| Ow 43 | 17 | 1 | 1 | | 30 | 2 | | 2 | | 5 | | | | | | | | | 142 |
| Ow 44 | 15 | | | | 38 | | | | | | 3 | | | | 1 | | | | 143 |
| Ow 45 | 9 | | | | 47 | | | | | 3 | | | | | 15 | | | | 126 |
| Ow 46 | 4 | | | | 17 | | | | | 1 | 2 | 3 | | | | | | | 173 |
| Ow 47 | 7 | 1 | | | 15 | | 2 | | | 2 | | 7 | | | 2 | | | | 164 |
| Ow 48 | 20 | 3 | | | 1 | | 22 | | | 1 | 3 | | | | | | | | 150 |
| Ow 49 | 3 | | | | 33 | 1 | | 1 | | 3 | 3 | | | | 2 | | | | 154 |
| Ow 50 | 6 | | | | 31 | 1 | | | | 3 | 1 | | | 4 | 3 | | 2 | | 149 |
| Ow 51 | 1 | | | | 22 | | | 3 | | 3 | 1 | 9 | | | 8 | | | 11 | 142 |
| Ow 52 | 6 | | | | 24 | | | | | 5 | 2 | 3 | | | 6 | | 3 | 9 | 142 |
| Ow 53 | 1 | | | | 38 | | | 3 | | 3 | | 2 | | | | | | | 153 |
| Ow 54 | 5 | 2 | | | 20 | 1 | | 2 | | 3 | 1 | 2 | | | 10 | | | 20 | 134 |
| Ow 55 | 9 | 1 | | | 29 | | | | 2 | 1 | 1 | | | | 2 | | | | 155 |
| Ow 56 | 1 | | | | 27 | | | 1 | | 1 | 3 | 5 | | | 2 | | | | 160 |